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OUTLOOK & SITUATION

Highlighted in this Issue: ENERGY

Contents

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Summary

With much of the former PIK acreage returned to production, farmers' use of energy, agricultural chemicals, seed, machinery and equipment, and other manufactured inputs is up this year, compared with 1983. As of early June, field crop acreage was estimated at 284 million acres, almost 30 million acres more than 1983 plantings. However, a late, wet spring, continued high interest rates, and a record farm debt/asset ratio have kept fertilizer, pesticide, and farm machinery purchases lower than previously forecast for the 1984 crop year. Farmers now are expected to spend just under $41 billion on manufactured inputs in 1984, compared with about $37 billion in 1983.

Farmers face a much improved energy outlook from recent years. Fuel of all types is plentiful, and per-gallon prices are holding steady at $1.17 for regular, farm bulk-delivered gasoline; $1.21 for retail unleaded gasoline; $1.01 for diesel fuel; and 77 cents for LP gas. Natural gas prices have leveled off, signaling more stable near-term prices for nitrogen fertilizer. The average world price of oil may actually decline over the next 2 to 3 years. Electricity prices, although forecast to increase, should only rise moderately over the next few years.

Hostilities between Iran and Iraq presently pose no serious problem directly for U.S. oil supplies, since the United States no longer heavily depends on oil imports from the Persian Gulf. Further, the U.S. Strategic Petroleum Reserve is well-stocked with 400 million barrels of oil, which would last 800 days if all Middle East oil supplies were cut off. Indirect impacts would occur if the United States had to share this oil under the International Energy Agreement.

The currrent farm energy situation contrasts sharply with that of the late 1970's and the first few years of the 1980's. Energy price increases between 1978 and 1982 were far higher than general price increases, with gasoline and diesel fuel prices more than doubling. Farmers' expenditures (adjusted for inflation) for energy and petroleum increased 20 percent during that period, while spending in real terms for most other farm production items decreased. The jump in farm energy expenditures contributed to the trend in on-farm energy conservation that continues today.

Nominal expenditures for farm machinery purchases, leases, and rentals in 1984 are expected to rise 2.5 percent to $8.1 billion, less than forecast earlier this year. Contributing to the lower projection are high farm machinery prices and interest rates, and financially stressed farmers' inability to assume new debt. Farm tractor sales in the first 6 months of 1984 were 3.4 percent greater than during the same period in 1983. Purchases of other machinery declined. Combines were down 25.6 percent; mower conditioners, 13.6; forest harvesters, 24.7; and balers, 14. This occurred primarily because of reductions in 1983 sales incentives, increased interest rates, and changes in Government programs.

Fertilizer use in 1983/84 still is expected to increase substantially over 1982/83. However, spring rains delayed planting and reduced preplant fertilizer applications. Plant nutrient use this year will be up about 14 percent, reflecting application of about 10.5 million tons of nitrogen, and 4.7 and 5.6 million tons of phosphate and potash. Farm prices for fertilizer are up an average of 7 percent from a year earlier. Supplies of all fertilizer materials are adequate, with nitrogen fertilizer imports up 47 percent from last year.

U.S. farmers are expected to use 506 million pounds (active ingredient) of pesticides during the 1984 crop year. Projected herbicide use, at 432 million pounds, is down 5 million pounds from the earlier forecast due to changes in planting intentions late in the season. Insecticide and fungicide use should equal about 67 and 7 million pounds, respectively. While herbicide prices declined an average of 6 percent from May 1983 to May 1984, insecticide prices are up 1 percent. Pesticide supplies are sufficient to meet this year's increased demand. Alachlor, a major farm herbicide, is slated to be reviewed by the Environmental Protection Agency for possible regulatory action.

ENERGY

Farmers' use of energy and other manufactured inputs is up this year from 1983, primarily because much of the formerly idled PIK acreage has been returned to production. Current field crop acreage is estimated at 284.3 million acres, almost 30 million acres more than 1983 plantings. Farm energy expenditures are expected to increase about 10 percent over last year's $9.9 billion.

The energy situation in the agricultural sector and in the rest of the economy continues to be more favorable than in recent years. Despite hostilities between Iran and Iraq, petroleum supplies are plentiful and prices remain firm. As we enter the third quarter, farmers face stable gasoline and diesel prices, which are expected to remain firm for the rest of this year. The June 1984 price of farm-delivered bulk leaded gasoline decreased $0.01 from the May price, to $1.17 per gallon, while the per gallon price of diesel fuel rose $0.01 to $1.01, and the price of unleaded gasoline purchased at service stations remained unchanged at $1.21 per gallon.

Current Energy Issues

Opinions differ regarding effects of increased hostilities between Iran and Iraq on U.S. and world petroleum supplies. For example, the Saudi Arabian Oil Minister recently stated that the West will lose about 4 million barrels of oil a day if exports from the Persian Gulf are shut off completely. On the other hand, the British Energy Minister stated that EC oil stocks are adequate and that considerable underutilized capacity in countries outside the Gulf can be mobilized to deal with the crisis.

Approximately 8 million barrels of oil a day flow through the Persian Gulf. While the United States is an integral part of the world oil market and would be affected by any significant curtailment of supplies from the Middle East, it does not import large quantities of oil from the warring Persian Gulf area. The United States also has over 400 million barrels of oil in the Strategic Petroleum Reserve (SPR), which would diminish the effects of a supply disruption. According to the Department of Energy (DOE), the SPR as of May 19, 1984, would last 80 days if all oil imports to the United States were suspended; 240 days if OPEC oil imports were cut off; and 800 days if all Middle East oil imports were cut off. Based on the performance of the petroleum spot market, the events in the Gulf have not had a serious effect on petroleum supplies. The spot market price for oil is expected to remain close to the official price of $29 a barrel for Arabian light crude.

Another area of uncertainty is the price impact of partial natural gas deregulation scheduled to go into effect January 1, 1985. Although some analysts project natural gas prices could increase 9 to 12 percent following deregulation, this is a minority view. Most experts anticipate prices competitive with fuel oil and do not anticipate any significant price increases as a result of decontrol.

The prices farmers will face for their energy inputs depend upon events in other sectors of the domestic economy and in the world. At this time, energy specialists agree that, in the short run, supplies will remain plentiful and prices steady.

Energy Prices

The Department of Energy in its recent *Annual Energy Outlook* reported slight declines in the average world oil price for the next 2 to 3 years and then a gradual rise in the real price, returning to about the 1980 level by the early 1990's. With respect to natural gas, the report indicates that because of market conditions in the last few years, most of the price effects expected to result from the deregulation of natural gas have already occurred. Therefore, in contrast with earlier forecasts, no significant gas price flareup is expected. This indicates that farmers should not expect significant increases in fertilizer prices as a result of natural gas deregulation. The U.S. demand for electricity is forecast to grow at a rate of about 4 percent more a year than general economic growth for the next decade. Electricity price increases, however, are expected to be moderate into the 1990's.

Farm Energy Expenditures

Energy is a significant portion of farm production expense. The amounts farmers spent for energy and petroleum products in 1982 and 1983 represented 7.5 and 7.3 percent, respectively, of total farm production expenditures. This contrasts with the pre-1979 era when spending for energy was well under 6 percent of total farm production expense.

The most comprehensive data on the status of agriculture are from the *Census of Agriculture*. A comparison of Census data for 1982 and 1978, the two most recent years that agricultural census data were collected, clearly reveals the changing status of energy as a farm production expense. Preliminary 1982 Census data show that there were 2.2 million farms in the United States with an average of 439 acres per farm. The number of farms in 1982 was 1 percent lower than in 1978.

Based on preliminary 1982 Census data, expenditures for energy and petroleum products increased relatively more than did expenditures for other inputs between the two most recent census years (table 1). In 1978, farmers spent a little over $6 billion on energy and petroleum products, while in 1982 they spent almost $10 billion, 66 percent more. Expenditures on energy and petroleum products for all farms averaged $2,669 a farm in 1978 and $4,450 a farm in 1982. In 1982, average expenditures for gasoline and gasohol averaged $1,333 a farm, expenditures on diesel fuel averaged $1,406 a farm, while expenditures on electricity averaged $911 a farm. In 1978, the average farmer spent $910 on gasoline and gasohol, $651 on diesel fuel, and $580 on electricity. (Energy expenditures reported here may differ from numbers reported in previous Outlook and Situation issues because of different data sources.)

Not all energy components increased the same magnitude between the two census years. Diesel fuel increased most. In 1978, farmers spent almost $1.5 billion on diesel fuel, while by 1982 their spending increased 114 percent to almost $3.2 billion. Electricity followed diesel fuel, with a 56-percent increase ($1.3 billion in 1978 and $2 billion in 1982). Expenditures on gasoline and gasohol also increased substantially. In 1978, expenditures on gasoline and gasohol were $2.1 billion, while in 1982 expenditures were almost $3 billion, a 45-percent increase.

Table 1.—Preliminary Agricultural Census data on U.S. farm energy and other selected input expenditures in 1978 and 1982

Selected expenditures	Nominal dollars 1978	Nominal dollars 1982	Change	Constant 1972 dollars[1] 1978	Constant 1972 dollars[1] 1982	Change
	Million dollars		*Percent*	*Million dollars*		*Percent*
Livestock and poultry	16,039	17,111	7	10,663	8,271	−22
Feed for livestock and poultry	15,786	18,574	18	10,495	8,978	−14
Seeds, bulbs, plants, and trees	2,607	3,174	22	1,733	1,534	−11
Commercial fertilizer	6,331	7,690	22	4,209	3,717	−12
Other agriculture chemicals (primarily pesticides)	2,890	4,283	48	1,921	2,070	8
Hired farm labor	6,814	8,434	24	4,530	4,077	−10
Contract labor	899	1,106	23	598	535	−11
Customwork and machine hire	1,751	2,025	16	1,164	979	−16
Energy and petroleum products:	6,026	9,974	66	4,006	4,821	20
Gasoline and gasohol	2,055	2,987	45	1,366	1,444	6
Diesel fuel	1,469	3,150	114	977	1,523	56
Electricity	1,308	2,041	56	870	986	13
Other	1,193	1,796	50	793	868	9
	Number					
Machinery and equipment:						
Motor trucks including pickups	3,435,298	3,357,829	2	NA	NA	NA
Wheel tractors	4,525,373	4,626,228	−2	NA	NA	NA
Grain and bean combines	664,276	654,694	−2	NA	NA	NA

[1]Based on GNP implicit price deflator.

NA = Not applicable or not available.

Source: Census of Agriculture, 1982: Preliminary data (Machine-readable data file) provided by Bureau of Census--Washington: Bureau of Census (Producer and Distributor), 1983.

The discussion so far is based on nominal dollars. In making comparisons between years, it is helpful to account for inflationary forces, so that examination of changes can be in real terms. The expenditures reported above were deflated by the GNP implicit price deflator, a relatively broad index, which stood at 150.42 in 1978 and at 206.88 in 1982. Real energy and petroleum expenditures increased 20 percent between 1978 and 1982. During this period, gasoline and gasohol expenditures increased 6 percent; electricity, 13 percent; and diesel fuel, 56 percent. In contrast, when measured in constant dollars, most of the other expenditures shown in table 1 actually were lower in 1982 than in 1978.

The large, nominal and real increases in expenditures for energy and petroleum products occurred despite a significant drop in the farm demand for fuel between 1978 and 1982. Preliminary Census data indicate that acreage was 3 percent lower and the number of wheel tractors and grain and bean combines on farms was 2 percent lower in 1982 compared with 1978. These factors, coupled with the recent trend of energy conservation on farms, reduced farm energy use over the two census years. Farm use of gasoline decreased one-third from 3.4 billion gallons in 1978 to 2.4 billion gallons in 1982. On-farm diesel fuel consumption decreased proportionately less—from 3.7 to 2.9 billion gallons over the same period.

Since energy use decreased between 1978 and 1982, the increased contribution of energy to total production expenditures was due to the large energy price increases that occurred between the two census years. The average price of unleaded gasoline sold at gas stations increased 101 percent; the average price of regular gasoline sold bulk to farmers was 106 percent higher; and the diesel fuel price increased 140 percent. The 1978 to 1982 price increase for energy products was considerably higher than the increase in the general price level within the economy. For the same period, the gross national product (GNP) implicit price indicator increased only 38 percent.

That energy expenditures increased while most other expenditures decreased in real terms indicates a need to keep improving the efficient use of energy in agriculture. However, over the long run, a variety of factors will affect farm energy use. For example, energy sources like wind, solar, wood, and methane gas produced from

manure may offer viable alternatives in some situations. Meanwhile, improved efficiency is being achieved in the use of energy for tillage, irrigation, and other agricultural practices. Farmers have sought to assure an adequate fuel supply through the activities of their farmer-owned cooperatives. Environmental and energy tax legislation also will affect the future availability and cost of energy used in agricultural production. The impacts of some of these trends are discussed in the special articles that follow.

U.S. Cooperative Involvement In The Petroleum Industry, 1982

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Abstract: Farmer-owned cooperatives are a principal source of petroleum product supply to farmers. A 1982 Agricultural Cooperative Service (ACS) survey finds that, in recent years, cooperative refineries have increased production efficiency, cooperative reserves of crude oil have been increased, and dependence on uncertain sources of supply has been decreased. Although vulnerabilities in the system remain, these trends contribute to the reliability of fuel supply to rural America.

Keywords: Cooperatives; petroleum; refining.

Figure 1

Cooperative Involvement in Various Activities in the U.S. Petroleum Industry, 1982

Activity	Local cooperatives	Regional cooperatives	International cooperatives
Oil exploration	None	Limited	Limited
Crued oil production	None	Limited	Limited
Refining	None	Four regional owned refineries: Cenex (1), Farmland (2), Indiana Farm Bureau (1)	Two interregional owned refineries: National Cooperative Refinery Association, Texas City Refining Inc.
Pipelines	None	Own or lease limited mileage of gathering and trunk lines	Own or lease limited limited mileage of gathering and trunk lines
Wholesale distribution	Limited to a few large locals	Extensive network of storage and distribution throughout most farming regions	Moderate level of sales or transfers to noncooperative wholesalers
Farm sales	Extensive bulk delivery and pump station operations	Extensive bulk delivery and pump station operations	None
Nonfarm and urban sales	Substantial in some markets and rural communities	Substantial in some markets and rural communities	None

Agricultural production on U.S. farms consumed approximately 2.4 billion gallons of gasoline, 3.6 billion gallons of middle distillate fuels (diesel and heating oil), and 1.1 billion gallons of LP gas in 1982. Farm use of fuel represents about 2.4 percent of total U.S. gasoline usage, 8.8 percent of total U.S. distillate use, and 4.9 percent of total U.S. LP gas use (2). Farmers purchase petroleum products, primarily in bulk, from various types of suppliers. A principal source of supply is the farmer-owned cooperative.

In 1982, USDA's Agricultural Cooperative Service (ACS) surveyed the 20 primary regional and interregional cooperatives whose combined volume represents approximately 95 percent of all petroleum products delivered for retail distribution through the cooperative system. This study is the fourth in a series on petroleum operations of U.S. regional cooperatives (1).

Farmer-owned cooperatives play a major role in providing petroleum-based fuels to U.S. farms. The farmer cooperative system is composed of over 2,800 autonomous businesses, operating under a variety of organizational arrangements at each level of the petroleum industry from crude oil exploration through retail sales (figure 1). Interregional cooperatives are owned by groups of regional cooperatives. Regional cooperatives, if federated, are owned by local cooperatives, and if centralized, owned directly by farmers. In all cases, control ultimately rests in the hands of U.S. farmers.

Crude Oil Production by Cooperatives

Cooperatives produced 7.9 million barrels of crude oil and 27.4 billion cubic feet of natural gas in 1982 (table 2). The crude oil production, representing only 0.25 percent of U.S. domestic oil production in 1982, provided 9 percent of the crude oil delivered to cooperative refineries.

In response to oil shortages in 1979, cooperatives moved to increase their crude oil reserves (table 2). While cooperative production of crude oil fell slightly between 1979 and 1982, proven reserves held by cooperatives increased 86 percent. Meantime, cooperatives tripled their production of natural gas.

Refining

Cooperative oil refining underwent major changes between 1979 and 1982. Two of the eight cooperative refineries doing business in 1979, Energy Cooperative, Inc., (ECI) in East Chicago and a small Farmland Industries plant in Scotts Bluff, Nebraska, ceased operations. ECI, an interregional refining cooperative owned by several regional cooperatives, was forced into bankruptcy due to high interest rates and extremely high crude oil costs. Because of the closures, the total daily refining capacity of cooperatives declined 30.7 percent, from 459,700 b/cd (barrels per calendar day) in 1979 to 318,350 b/cd in 1982. The mix of products produced in cooperative refineries also changed.

Table 2.—Cooperative crude oil and natural gas production and reserves, 1979 and 1982

Item	Unit	1979	1982
Crude oil production	Barrels	8,683,715	7,926,165
Crude oil reserves	Barrels	52,025,000	96,776,571
Natural gas production	Thousand cubic feet	9,877,000	27,387,163
Natural gas reserves	Thousand cubic feet	NA	322,221,550

NA = not available.

Table 3.—Cooperative refinery inputs and products produced, 1979 and 1982

Input or product	1979	1982
	Thousand barrels	
Inputs:		
Crude oil, run or processed	138,258	84,625
Natural gas liquids, run or processed	1/	5,082
	Thousand gallons	
Products produced:		
Unleaded gasoline	697,760	1,009,548
Leaded gasoline	2,212,047	989,164
Kerosene	316,714	169,912
Diesel fuel and heating oil	1,487,771	1,062,606
Residual oil	175,635	282,568
Other liquids	58,723	94,363
Total liquids	4,948,650	3,608,161

[1]Included in crude oil total for 1979.

In 1982, cooperatives refined 2.1 percent of all the crude oil and natural gas entering U.S. refineries. Cooperative refineries processed 84.6 million barrels of crude oil and 5.1 million barrels of natural gas liquids in 1982, down 35.1 percent from the 1979 peak (table 3). Production of unleaded gasoline increased 44.7 percent to 1.01 billion gallons, while production of leaded gasoline declined 55.3 percent to 989 million gallons. Diesel fuel and heating oil production fell 28.6 percent from 1.49 billion gallons in 1979 to 1.06 million gallons in 1982, due largely to the loss of ECI's large diesel volume.

Cooperative production of total petroleum liquids fell 27.1 percent from 1979 to 3.61 billion gallons in 1982, reflecting a significant, though smaller proportional decline, for the entire U.S. refining industry. The U.S. refining industry, as a whole, has experienced increased efficiency. The fact that cooperative refinery input declined more than output illustrates improved efficiency in the cooperative refining system. This improvement is due to closing of less efficient plants and fine tuning of remaining ones (table 4).

Even though cooperatives increased their crude oil reserves after 1979, their refineries remained highly vulnerable to disruptions in crude oil supplies (table 5). In 1982, cooperative refineries obtained only 11.9 percent of their total input requirement from cooperative-controlled reserves. Spot market purchases represented 30.7 percent, while short-term contracts (less than 1 year) represented 19.3 percent, and long-term and foreign contracts accounted for 38.1 percent of crude oil input. Many of the contracts contained clauses allowing for nondelivery in the event of a major disruption.

In response to supply uncertainty, cooperative refineries expanded their crude oil storage capacity 42 percent to

Table 4.—Productivity of U.S. and cooperative refineries by major product class, 1979 and 1982

Item	All U.S. refineries[1] 1979	All U.S. refineries[1] 1982	Cooperative refineries 1979	Cooperative refineries 1982
	Thousand barrels per day			
Refinery inputs:				
Crude oil	14,648	11,774	360.0	231.9
Liquified petroleum gas	236	300	18.9	13.9
Total	14,884	12,074	378.9	245.8
Products:				
Finished gasolines	6,852	6,338	189.7	130.3
Distillate fuels	3,153	2,606	133.0[2]	75.5
Residual fuels	1,321	1,070	2/	18.4
Products as a percent of inputs:				
Finished gasolines	46.0	52.5	50.1	53.0
Gasoline and distillates	67.2	74.1	NA	88.5
Gasoline, distillates, residual oil	76.1	82.9	85.2	95.7

NA = not available.

[1]Source: (2). [2]Residual fuel oils included in distillate total in 1979.

Table 5.—Sources of crude oil received by cooperative refineries, 1982

Source	1,000 barrels	Percent
Cooperative reserves	9,994	11.9
Domestic spot purchases	9,909	11.8
Domestic contracts (short-term)	16,261	19.3
Domestic contracts (long-term)	24,480	29.1
Foreign spot purchases	15,905	18.9
Foreign source contracts	7,562	9.0
Total	84,111	100.0

Table 6.—Refinery bulk storage capacities, 1979 and 1982[1]

Type of storage	1979	1982	Percent change
	Thousand barrels		
Crude oil	3,784	5,373	42.0
Motor gasoline	2/	7,119	NA
Distillate fuel and kerosene	2/	4,558	NA
Residual fuel oil	2/	699	NA
Refined liquid fuels	15,822	12,376	−21.8
LP gas	NA	2,678	NA
Lubricating oils, asphalt, blending stock, other	NA	313	NA

NA = not available.

[1]Capacity at refinery sites and other locations. [2]Combined figure only for 1979.

Table 7.—Quantity of petroleum products delivered by regional cooperatives to cooperative and noncooperative final outlets, 1982

Product	Total deliveries	Type of outlet: Cooperative	Type of outlet: Non cooperative
	Thousand gallons	*Percent*	
Unleaded gasoline—regular	455,982	75.5	24.5
Unleaded gasoline—premium	15,956	59.3	40.7
Leaded gasoline—regular	1,421,739	82.6	17.4
Ethanol blends and leaded premium	20,602	77.7	22.3
Total motor gasoline	1,914,279	80.6	19.4
Kerosene	63,430	86.2	13.8
Heating and diesel fuel	1,516,501	86.5	13.5
Other distillates	200,031	76.7	23.3
Total distillates	1,779,962	85.4	14.6
LP Gas	723,799	98.3	1.7
Lubricating oil	36,212	70.6	29.4
Grease (tons)	7,892	86.5	13.5

5.37 million barrels between 1979 and 1982 (table 6). Over the same period, storage capacity for refined liquid fuels fell 21.8 percent, to 12.38 million barrels, due to refinery closings.

Wholesale Operations

The regional cooperatives surveyed play a major role in wholesale distribution of petroleum products to agricultural markets. The majority of wholesale deliveries by regional cooperatives went to final retail outlets owned and operated by cooperatives (table 7).

Table 8.—Distribution of cooperative wholesale petroleum deliveries, by region, 1982

Region	Motor gasoline	Distillate fuels	LP gas	Lubricating oils	Total
			Percent		
Northeast	11.7	18.2	5.3	16.9	13.2
Lake States	17.1	16.3	19.2	12.4	17.1
Corn Belt	30.5	29.2	37.6	17.1	31.1
Northern Plains	19.7	17.5	25.9	17.2	19.9
Appalachian	4.9	5.0	2.8	1.2	4.6
Southeast and Southern Plains	4.5	4.4	2.8	22.3	4.3
Delta States	2.1	1.9	1.5	5.7	1.9
Mountain and Pacific	9.6	7.6	4.9	7.0	8.0

Over 80 percent of motor gasoline deliveries and 85 percent of distillate deliveries by regional cooperatives went to final outlets operated by local or regional cooperatives, with the bulk going to outlets operated by local cooperatives. Eighty-four percent of motor gasoline, 77 percent of distillates, and 92.3 percent of LP gas went to local cooperatives, with the remainder delivered to outlets operated by centralized regional cooperatives.

The Corn Belt, Northern Plains, and Lake States received the largest shares of petroleum products delivered by regional cooperatives (table 8). These regions also have the greatest agricultural demand for petroleum products.

The regional cooperatives surveyed operated 1,152 trucks (2,000+ gallon capacity) in their distribution operations. These vehicles logged 36.2 million miles in 1982. The regionals operated 110 liquid fuel and LP gas storage terminals, with a total capacity of 548 million gallons.

Regional cooperatives delivered petroleum products to thousands of final outlets throughout the United States (table 9). Petroleum bulk delivery centers represented the most important group, both in number and volume, though customer fill stations were also of considerable importance.

Wholesale operations of regional cooperatives relied on cooperative refineries for most of their petroleum product supplies in 1982 (table 10). Most of the products were transported to regional terminals from cooperative refineries directly via pipeline and truck. A considerable portion, however, was received through various product transfer or swapping arrangements between cooperative refineries and noncooperative refineries when geographic or market circumstances warranted.

Implications for Farmers

While cooperatives have moved to decrease their vulnerability to crude oil supply disruptions, the possibility of such disruptions remains a grave concern to cooperatives and their farmer-owners, as well as independent noncooperative refiners and wholesalers serving rural markets. The ability of the rural petroleum delivery system to access supplies during crucial planting and harvesting periods is vital to the security of the U.S. food system. The continuing withdrawal of major oil companies from nonprofitable rural petroleum markets can further weaken the delivery system. Thus, the way in which cooperatives adapt to changing world petroleum markets is of great importance to U.S. farmers.

Table 9.—Number of petroleum product final outlets delivered to by regional cooperatives, 1982

Product/outlet operator	Type of outlet: Bulk delivery centers	Customer fill stations
	Number	
Refined liquid fuels:		
Regional owned	322	236
Local cooperative owned	3,612	2,800
Noncooperative owned	327	603
LP gas:		
Regional owned	176	13
Local cooperative owned	1,498	645
Noncooperative owned	4	0

Table 10.—Source of petroluem products for regional cooperative wholesale operations, 1982

Product	Source: Cooperative refineries	Spot purchases	Contracts with non-cooperative suppliers
	Percent		
All motor gasoline	75.9	13.5	10.6
Kerosene	83.6	10.8	5.6
Heating and diesel fuels	70.8	16.4	12.8
LP gas	10.3	18.2	62.2
Lubricating oils	59.6	5.1	35.4
Grease	47.6	32.5	19.9

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Alcohol Fuels in the U.S.: Status and Prospects [1]

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Abstract: A variety of incentives have been provided to encourage development of the domestic fuel ethanol industry. Corn is currently the premium feedstock for ethanol production because it is relatively abundant, easy to convert into ethanol, and relatively inexpensive. Ethanol production cost depends on various factors such as cost of feedstock, costs and type of energy used, plant investment costs, size of the plant, and production technology. The market for ethanol depends heavily upon the prices of gasoline and corn. Unless gasoline prices rise and/or corn prices fall substantially, alcohol blends will remain competitive with gasoline only with Federal and State subsidies. The outlook for continued subsidies is uncertain. Reducing lead in gasoline should sustain ethanol demand because of its octane-boosting characteristic. Ethanol fuels will continue to be produced by large-scale commercial facilities since small-sized, on-farm alcohol production has not been profitable. A stable, domestic capacity for alcohol fuel production would provide a hedge against unforseen disruption of the Nation's petroleum supplies.

Keywords: Ethanol, fuel, tax exemptions, ethanol-gasoline blend, octane booster, gasoline prices.

Introduction

Producing ethanol from domestically abundant and renewable resources is one way of reducing U.S. dependence on imported oil. Even though such reliance has decreased to 28 percent in 1983 from a peak of 46.5 percent in 1977 (11), foreign dependence is still a concern. Federal and State programs support development of alternative fuels such as ethanol.

Interruptions in the fuel supply disrupt the whole economy, but can be particularly damaging to agriculture. The critical seasonal need for fuel during planting and harvesting seasons make agriculture vulnerable to even brief shortages at these times. Ethanol (ethyl alcohol) and methanol (methyl alcohol) have been suggested as alternative fuels because they can be produced from biomass.

Ethanol production is discussed and the overall current situation and near-term outlook for fuel ethanol in the United States are assessed. Although methanol can be made from biomass, the technology is not yet commercial.

Tax Incentives and Other Government Assistance

The Energy Tax Act of 1978, the Crude Oil Windfall Profit Tax Act of 1980, the Energy Security Act of 1980, and the Surface Transportation Assistance Act of 1982 promulgated a variety of Federal financial incentives to develop a domestic ethanol fuel industry. Current incentives include: (1) exemption of alcohol from part of the Federal gasoline excise tax, (2) Federal income tax credits, (3) Federal investment tax credits, and (4) Federal loan guarantees for alcohol fuel production facilities. Alcohol is also exempt from part or all of many State gasoline excise taxes.

Federal Gasoline Excise Tax Exemptions

Blends of one part alcohol and nine parts gasoline, known as gasohol, are exempt from 5 cents of the 9-cent-per-gallon Federal gasoline excise tax, which continues through December 31, 1992.[2] This subsidy increases to 6 cents a gallon under the Tax Reform Act of 1984, PL-369. The 6-cent exemption will take effect January 1, 1985, and expire December 31, 1992. Fuels containing at least 85 percent ethanol, methanol, or other alcohol will be exempt from the entire 9-cent-per-gallon Federal gasoline excise tax if the alcohol is produced from substances other than petroleum or natural gas. This exemption also will continue through 1992.

Federal Income Tax Credits

Individuals who sell or use blended or unblended (neat) alcohol in their trade or business may claim income tax credits for alcohol derived from substances other than petroleum, natural gas, or coal. Amounts claimed must be reduced by the amount of any Federal gasoline excise tax exemption applicable to the fuel. Total income tax credits equal 50 cents a gallon for alcohol of 190 proof or

[1]Nancy L. Smith and Gerald Grinnell of the USDA Office of Energy supplied data, information, and review that made valuable contributions to the preparation of this article.

[2]The Federal gasoline excise tax (from which the exemption is taken) expires at the end of 1988. The exemption would have no value if the excise tax is not extended.

above and 37.5 cents for alcohol of 150 to 189 proof. These credits went into effect April 1983 and will continue through 1992 (6). The Tax Reform Act increases these credits to 60 cents and 45 cents, respectively.

Investment Tax Credits

Facilities for alcohol production may qualify for two investment tax credits: (1) a 10-percent energy credit for facilities completed before December 31, 1985, which use a primary energy source other than petroleum products or natural gas, and (2) the permanent 10-percent business investment tax credit (6).

Loan Guarantees

The Federal Government also guarantees loans for alcohol facilities. The Farmers Home Administration of USDA currently has obligations of $280 million for 21 projects, with annual capacity of 225 million gallons of alcohol (7). The Department of Energy has an obligation of $42.3 million for one 50-million gallon plant and is negotiating loan guarantees with 5 applicants to produce 120 million gallons of fuel alcohol a year.

State Tax Exemptions

In addition to Federal incentives, 32 States currently exempt fuels containing alcohol from part or all of their gasoline excise taxes. State gasoline excise tax exemptions vary, ranging from 1 cent a gallon in Connecticut and Nevada to 11 cents in New Mexico (table 11). The unweighted average of State exemptions is 4.5 cents per gallon of ethanol-gasoline blend for those States having exemptions in 1984.

Ethanol Production

The feedstocks that can be used to produce ethanol, by well-established fermentation technology, include starch and sugar crops and their residues, and cellulosic materials. Corn, wheat, grain sorghum, and potatoes are the principal starch crops used. Fruits, sugarbeets, sugarcane, and sweet sorghum are the major sugar crops. Although cellulosic feedstocks (such as wood, corn stover, and straw) have potential, the technology to convert them into ethanol has not reached the commercial stage.

In general, grain feedstocks are much less expensive than sugar crops and potatoes. Corn is the primary feedstock for ethanol production because it is abundant, easy to convert, and relatively inexpensive. Ethanol cost estimates vary with assumptions about feedstock and byproduct prices, operating costs of ethanol plants, prices of gasoline and alternative octane boosters, and the existence and value of Federal and State subsidies and other financial incentives. Net feedstock costs to produce a gallon of ethanol are detailed in table 12.

The effect of corn prices on the cost of ethanol production is shown in table 13, with a gallon of ethanol costing between $1.36 and $1.88 when corn costs between $2 and $4 a bushel.

Production costs depend on the milling process used. Currently, 57 percent of fuel ethanol capacity is by wet milling, 41 percent by dry milling, and 2 percent by other

Table 11.—Market penetration rates and net State gasoline excise tax exemptions for ethanol/gasoline blends

State	Market penetration in 1983[1]	State exemption[2] 1983	State exemption[2] 1984[3]	Exemption as percent of State excise tax, 1984[3]
	Percent	*Cents per gallon*		*Percent*
Alabama	1.6	3	3	27
Alaska	NA	8	8	100
Arizona	4/	–	–	–
Arkansas	1.1	6.5	4.7	49
California	4.4	3	3	33
Colorado	3.6	5	5	42
Connecticut	0.1	1	1	7
Delaware	NA	–	–	–
Florida	7.0	4	4	41
Georgia	4/	–	–	–
Hawaii	NA	4	4	47
Idaho	NA	4	4	28
Illinois	12.5	5/	5/	18
Indiana	23.2	5/	5/	27
Iowa	36.6	5/3[6]	3/2[6]	23
Kansas	5.4	2/4[6]	5	45
Kentucky	5.8	3.5	3.5	35
Louisiana	NA	8	8	100
Maine	NA	–	–	–
Maryland	4/	0/3[6]	3	22
Massachusetts	4/	–	–	–
Michigan	15.4	5/4[6]	4	27
Minnesota	0.2	0/2[6]	2	12
Mississippi	NA	–	–	–
Missouri	NA	–	–	–
Montana	NA	7	7	47
Nebraska	23.6	5	5	32
Nevada	4/	1	1	8
New Hampshire	0.8	5/0[6]	–	–
New Jersey	NA	–	–	–
New Mexico	3.6	10/11[6]	11	100
New York	NA	–	–	–
North Carolina	0.1	5	5	42
North Dakota	1.1	4	5	38
Ohio	9.9	3.5	3.5	29
Oklahoma	4.0	–	–	–
Oregon	0.1	–	–	–
Pennsylvania	NA	–	–	–
Rhode Island	NA	–	–	–
South Carolina	4/	–	–	–
South Dakota	8.2	4	4	31
Tennessee	9.9	4	4	44
Texas	3.4	5/2.7[6]	5	100
Utah	4.0	5	5	45
Vermont	NA	–	–	–
Virginia	1.8	8	8	73
Washington, D.C.	NA	–	–	–
Washington	0.4	1.5	1.6	10
West Virginia	NA	–	–	–
Wisconsin	4/	–	–	–
Wyoming	4/	4	4/0[6]	50
U.S.	4.4			

NA = not applicable

– = no State exemption

[1]Percent of total gasoline sales represented by alcohol/gasoline blends. [2]Amount exempted from State gasoline excise tax for alcohol/gasoline blends. [3]As of May 1984. [4]Less than 0.1 percent. [5]Exemption calculated as percent of sales. [6]Exemption changes during year from first figure to second.

Source: (2, 13).

Table 12.—Feedstock costs for ethanol production in the United States, 1983

Item	Corn	Grain Sorghum	Wheat	Potatoes	Sugarbeets	Sugarcane	Sweet potatoes
Feedstock price[1]	$2.99/bu	$2.74/bu	$3.59/bu	$5.69/cwt.	$41.07/ton	$28.31/ton	$12.30/cwt.
Ethanol yield[2]	2.6 gal/bu	2.6 gal/bu	2.6 gal/bu	1.4 gal/cwt.	20.3 gal/ton	17 gal/ton	2.35 gal/cwt.
Feedstock cost per gallon of ethanol	$1.15	$1.05	$1.38	$4.06	$2.03	$1.67	$5.23
Byproduct yield	16.8 lbs/bu	16.8 lbs/bu	20.7 lbs/bu	3/	264 lbs/ton	3/	3/
Byproduct price	$156.56/ton	$156.56/ton	$156.56/ton	3/	$125/ton	3/	3/
Byproduct credit per gallon of ethanol	−$.51	−$.51	−$.62	3/	−$.78	3/	3/
Net feedstock cost per gallon of ethanol	$0.64	$0.54	$0.76	$4.06	$1.25	$1.67	$5.23

[1]Prices received by farmers during the 1983 calendar year. [2]USDA, Motor Fuels from Farm Products, misc. publication no. 327, December 1938. [3]Byproduct is of limited monetary value.

Table 13.—Estimated ethanol production costs per gallon for a 40-million-gallon-a-year plant for various corn prices, 1983

	Price of corn (dollars per bushel)				
Cost item	$2.00	$2.50	$3.00	$3.50	$4.00
			Dollars per gallon		
Feedstock	.77	.96	1.15	1.35	1.54
Other costs:					
Variable[1]	.48	.48	.48	.48	.48
Fixed[1]	.49	.49	.49	.49	.49
Total	1.74	1.93	2.12	2.32	2.51
Less byproduct credit for distillers dried grain[2]	−.38	−.45	−.51	−.57	−.63
Total	1.36	1.48	1.61	1.75	1.88

[1]From table 14. [2]The distillers dried grain (DDG) price of $156.56 a ton is used for byproduct credits. The DDG credits increase with corn prices; in general, protein prices rise with corn prices. It is assumed that three-fourths of the increase in corn prices is reflected in DDG prices (4).

Assumptions:
- 2.6 gallons of ethanol produced per bushel of corn.
- 16.8 pounds of (DDG) per bushel of corn.
- Federal and State tax exemption not included.

Table 14.—Cost per gallon of corn-based ethanol production, 1983

	Ethanol plant size (million gallon)						
Cost	10	20	40	60	80	100	120
				Dollars per gallon[1]			
Energy	.29	.29	.29	.29	.29	.29	.29
Other direct	.16	.10	.07	.07	.06	.06	.06
Indirect	.23	.17	.12	.12	.10	.10	.10
Capital recovery	.71	.58	.49	.45	.42	.40	.38
Feedstock[1]	1.15	1.15	1.15	1.15	1.15	1.15	1.15
By-product credit[2]	−.51	−.51	−.51	−.51	−.51	−.51	−.51
Total	2.03	1.78	1.61	1.57	1.51	1.49	1.47

[1]Based on corn price $2.99 a bushel. [2]Based on distillers dried grain of $156.56 a ton.

Assumptions:
- Conversion yields of 2.6 gallons of ethanol and 16.8 pounds of high-protein byproducts per bushel of corn.
- Federal and State tax exemptions not included.
- Costs shown are for dry-milling production technology.

Source: (1). Cost estimates were updated to reflect 1983 costs and prices.

processes (9). Most ethanol will continue to be produced in facilities with a minimum production capacity of 10 million gallons. The cost per gallon of ethanol declines as plant size increases because of the technical efficiencies in the use of plant and equipment. As a result of technical efficiencies, distillation capacity can be increased without proportionally increasing plant investment and operating costs. Table 14 shows that economies of scale in ethanol production are substantial in the range of 10 to 40 million gallons per year. Although the scale economies continue beyond that size, the cost reduction becomes progressively smaller as the plant size is increased from 60 to 120 million gallons per year.

On-Farm Production of Ethanol

Of the available alternatives, on-farm production of ethanol initially was considered to be the most promising near-term farm energy production option for reducing farmers' dependence on purchased fuels. Consequently, ethanol production attracted the attention of farmers all over the Nation in the late 1970's and early 1980's. Despite this interest, small-scale, on-farm production of ethanol has not made a significant contribution to the Nation's fuel supply.

As many as 24 on-farm ethanol production plants have been in operation (14), but recently some have closed. The problem is that the scale of operation of these on-farm facilities is not efficient. For example, the typical on-farm plant can only distill 25 gallons an hour or less, which means its annual output is only around 50,000 gallons. Plants of this size are unable to capitalize on economies of scale available to commercial operations. Some of these plants manage to stay profitable because they enjoy special economic advantages, such as low-cost feedstock and fuel, on-farm consumption of stillage, and easy access to product markets. Others, however, must struggle and many have gone out of business. Consequently, the vast majority of ethanol is and will continue to be produced by large-scale commercial facilities.

Ethanol Demand

Total sales of ethanol-gasoline blends have more than doubled: 2.3 billion gallons were sold during 1982 compared with about 830 million during 1981. Sales rose again in 1983 to 4.3 billion gallons, marking an 87-percent increase over 1982 (2). Currently, most fuel ethanol is used in gasoline blends. Blends of one part anhydrous (water-free) ethanol and nine parts unleaded gasoline can be used without modifying existing engines. Ethanol improves combustion efficiency for some engines, boosts the octane rating of gasoline, and changes performance characteristics such as starting and emissions. Ethanol has an octane rating of 110-112 and can be used in place of tetraethyl lead to increase the octane rating of unleaded gasoline. In a 10-percent blend with gasoline, ethanol increases octane gasoline by 3 to 4 points. The precise degree of octane enhancement depends on the base octane rating and other chemical properties of the particular gasoline used in the blend. The octane enhancement property of ethanol has made it a potentially important substitute for lead additives, which are being phased out by the Environmental Protection Agency (EPA).

Determining the cost to improve octane is complicated by such variables as the volume, price, and Reid vapor pressure of the finished fuel; the cost of ethanol; and the octane of the base gasoline. Successive additions of ethanol will not yield identical octane increases in the fuel. Table 15 shows the costs of using various additives to increase a barrel of base gasoline by one octane point (5).

At the current 50-cent-a-gallon Federal subsidy, it costs 57.1 cents a barrel, or 1.4 cents a gallon, to increase unleaded regular gasoline by one octane number, using a 10-percent blend of ethanol. This compares with a cost of 48.6 cents a barrel, or 1.2 cents a gallon, for toluene used in a 4-percent blend. The cost for TBA (tertiary butyl alcohol) blended at 16 percent is 81.2 cents a barrel, or 2 cents a gallon. Methanol priced at 50 cents a gallon and blended at a 5-percent rate (although current law prohibits blending at this high a rate) would cost 41.5 cents a barrel, or about 1 cent a gallon, to increase unleaded regular gasoline by one octane number.

The EPA is proposing to reduce the amount of lead now allowed in leaded gasoline. This would increase the potential market for ethanol, but its penetration rate will depend on supply reliability; product acceptance and prices; gasoline prices; and above all, Federal and State subsidies.

Table 16 presents wholesale and retail prices for unleaded gasoline, wholesale prices for ethanol and computed wholesale and retail gasoline-alcohol blend prices for each month in 1983. Without Federal and State gasoline excise tax exemptions, it is estimated that retail prices for 10-percent-alcohol blend fuel would average about $0.084 higher than unleaded gasoline. These prices would compare with premium unleaded gasoline, which typically is priced about $0.08 to $0.10 more than regular unleaded. Alcohol blends frequently have a slightly lower octane rating than premium unleaded gasoline (10). With the 5-cent-a-gallon Federal gasoline excise tax exemption, it is estimated that costs of producing alcohol blends would have averaged $0.034 a gallon more than regular unleaded gasoline at retail in 1983. Ethanol-gasoline blends probably could compete with regular unleaded gasoline in States with subsidies greater than this amount.

The penetration of ethanol blends into State gasoline markets ranges from less than 0.1 percent to more than 36 percent in Iowa. Penetration appears to depend on several factors including: (1) the cost to produce ethanol in or deliver it to the State; (2) the share of gasoline sold by companies that blend alcohol with gasoline; (3) the amount of the State gasoline excise tax exemption; (4) the restrictions the State has on whether imported ethanol qualifies for the tax exemption; (5) the volume of ethanol produced in the State; and (6) the availability of imported ethanol.

Ethanol has penetrated little into States where the gasoline excise tax exemption is less than 3 cents a gallon. The 10 States with the highest penetration rates tend to be near corn production and have tax exemptions ranging from 3 to 5 cents a gallon (table 11). Florida (ranked ninth) is not near corn production, but is the recipient of low-priced ethanol imports. Some States that have high tax exemptions do not have large ethanol

Table 15.—Octane improvement costs

Additive	Volume	Cents per octane number for one barrel of gasoline (42 gallons)		
		Unleaded regular	Unleaded premium	Leaded regular
	Percent		*Cents*	
Ethanol @ $1.61/gal.	10.0	132.7	150.6	173.3
$.05/gal. subsidy	10.0	57.1	61.2	77.4[1]
$.10/gal. subsidy	10.0	– 18.4	– 28.2	– 18.5[1]
TBA @ $1.00/gal.	16.0	81.2	114.2	66.1
	8.0	88.5	125.5	72.0
Oxinol 50 @ $.70/gal.	9.6	5.4	0.0	9.7
	4.8	31.0	30.6	37.3
MTBE @ $1.00/gal.	11.0	45.1	49.0	41.7
	4.0[2]	48.8	52.6	45.2
Toluene @ $1.05/gal.	4.0[2]	48.6	53.7	44.0
Methanol[3] @ $.40/gal.	5.0	23.2	25.7	31.4
$.50/gal.	5.0	41.5	43.4	58.3
$.60/gal.	5.0	59.7	61.0	85.2
$.70/gal.	5.0	78.0	78.7	112.1

[1]Assuming subsidy applied to leaded gasoline. [2]4-percent Toluene or MTBE improves leaded regular by 1 octane number. [3]Methanol blend costs reflect a penalty for the low Btu content of the methanol, which increases the cost to the motorist.

Source: (5). Ethanol data revised to reflect current price.

Table 16.—Wholesale and retail prices of unleaded gasoline and alcohol fuel blends in the United States, 1983 (cents per gallon, excluding taxes)

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
Unleaded gasoline:													
Wholesale price	89.9	86.7	84.4	87.9	91.8	93.0	93.7	92.7	91.4	89.2	87.8	84.8	89.4
Retail price	101.1	96.4	93.8	97.7	99.6	100.6	101.2	100.7	99.4	97.7	96.2	94.6	98.3
Indicated price margin (%)	12.5	11.2	11.1	11.1	8.5	8.2	8.0	8.6	8.8	9.5	9.6	11.6	9.9
Ethanol:													
Wholesale price	170.0	170.0	166.0	165.0	165.0	165.0	165.0	165.0	165.0	165.0	168.0	170.0	166.6
10 percent alcohol blends:													
Indicated wholesale price[1]	97.9	95.5	92.6	95.6	99.1	100.2	100.8	99.9	98.8	96.8	95.8	93.3	97.2
Indicated retail price without Federal tax exemption[2]	110.1	105.6	102.9	106.3	107.5	108.4	108.9	108.5	107.5	106.0	105.0	104.1	106.7
With Federal tax exemption[3]	105.1	100.6	97.9	101.3	102.5	103.4	103.9	103.5	102.5	101.0	100.0	99.1	101.7
With Federal and State exemption[4]	100.6	96.1	93.4	96.8	98.0	98.9	99.4	99.0	98.0	96.5	95.5	94.6	97.2

[1]Computed using 0.9 (wholesale unleaded gasoline price) + 0.1 (wholesale ethanol price). [2]Computed using indicated unleaded retail margin applied to wholesale gasohol price. [3]$.05 per gallon of gasohol. [4]The unweighted average State gasoline excise tax exemption for the 33 States with an exemption in 1983 was $.045 per gallon (table 1).

Sources: (10, 14).

sales because they limit their exemption to domestically produced ethanol. For example, in New Mexico, which has an 11-cent exemption, little ethanol currently is being sold.

Fuel Ethanol Supply

Total anhydrous ethanol production capacity in the United States grew rapidly from 380 million gallons in 1981 to 764 million gallons in 1983 (3). Capacity is expected to reach 1 billion gallons a year by the end of 1986 if current Federal and State incentives and energy investment credits remain in effect and if corn and gasoline prices remain relatively stable.

Fuel Ethanol Imports

In 1983, imports accounted for 13 percent of the fuel ethanol consumed in the U.S. Brazil supplied the bulk of imported alcohol, with Argentina, Canada, West Germany, France, Norway, Spain and the United Kingdom supplying lesser amounts. Imports from Brazil were 58 and 56 million gallons in 1982 and 1983, respectively. Total fuel ethanol imports during the first 2 months of 1984 were 9 million gallons (3).

The Federal gasoline excise tax exemptions for ethanol fuels and most State subsidies do not distinguish between domestically produced and imported ethanol. In 1982, U.S. import tariffs were imposed to prevent ethanol from benefitting from the Federal subsidy. The tariff was implemented in steps. Since January 1, 1983, it has equaled the value of the Federal gasoline excise tax exemption. The Tax Reform Act of 1984, PL-369, increases the tariff to 60 cents a gallon of ethanol effective January 1, 1985. This would offset the new Federal gasoline excise tax exemption of 6 cents a gallon of blended fuel (arising from the 60 cents a gallon exemption of ethanol used at 10 percent in blends).

Outlook

Growth in the domestic ethanol industry has significant implications for the U.S. agricultural sector. Increased ethanol demand increases demand for corn, which in turn, increases the price, profitability, and production of corn and alters the production and consumption of other agricultural products (6).

However, increased corn prices, stimulated by increased demand for corn as an alcohol feedstock, have an adverse impact on the competitiveness of alcohol-gasoline blends with gasoline. This is because higher corn prices subsequently increase ethanol costs. A $1-a-bushel increase in the price of corn will increase ethanol costs approximately 20 cents a gallon.

Future prospects for the U.S. ethanol market heavily depend upon the relative prices of corn and gasoline. Market penetration of fuel alcohol was slowed by the drop in world crude oil prices from about $35 per barrel from 1980 to 1982 to about $29 per barrel in 1983-84. Unless corn prices fall and/or gasoline prices rise sharply, alcohol blends will remain competitive with gasoline only with Federal and State subsidies.

The outlook for continued subsidies is uncertain. The 10-percent Energy Investment Tax Credit (EITC) expires in 1985. Although new ethanol facilities will continue to qualify for the standard 10-percent business investment tax credit, they will not have the benefit of the additional 10-percent credit which the EITC provided. Losing this credit would mean higher costs to establish new ethanol facilities and could discourage some projects.

Future State action concerning ethanol could have a profound effect on the industry. Some States have restricted the sale of imported ethanol; others have limited the gasoline excise tax exemptions for ethanol produced either within the State or in States with which they have reciprocal exemption agreements. Because these exemptions mean States lose revenue, some States are expected to reduce or eliminate them before current expiration dates after increases in the Federal gasoline excise tax exemption contained in the Tax Reform Act becomes effective.

At current and foreseeable prices, Government subsidies will be required for ethanol to effectively compete in the marketplace. Proposed reductions in gasoline lead levels would stimulate demand for alternative octane enhancers including ethanol, but relative prices will determine which of the available alternatives will garner the market. An increase in ethanol demand would result in higher farm prices, but increased ethanol imports could dampen this impact. On the other hand, decreases in subsidies or continued slippage of gasoline prices would reduce ethanol's competitive position thus decreasing or eliminating any gains farmers could otherwise realize through ethanol sales.

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Groundwater Contamination from Underground Fuel Tanks

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Abstract: Current and proposed regulations to reduce the incidence of leakage from underground fuel storage tanks can prevent groundwater contamination but will cause tank owners considerable expense. Because agriculture has more underground fuel tanks than other industries, the costs of leak detection and prevention brought about by regulation may have significant impacts on some farmers.

Keywords: Fuel storage, underground fuel tanks, tank leakage, corrosion.

The U.S. Congress, the Environmental Protection Agency (EPA), and a number of States have examined, or are examining, possible regulation of underground fuel tanks. They are concerned that leaking tanks may be contaminating groundwater. The reason for this concern is that about half of this Nation's drinking water comes from underground sources. Farmers have more underground fuel tanks than any other industry, including gasoline service stations, and may be affected by the proposed regulations.

The Bureau of the Census estimates that nearly 1.5 million farms had gasoline storage tanks with a combined capacity of about 700 million gallons in 1979, the latest year for which data are available (16). More than 1 million farms had total storage capacity for 800 million gallons of diesel fuel, 838 thousand farms could store 560 million gallons of LP gas, and more than 500 thousand farms could store a total of about 200 million gallons of fuel oil for business use. Fuel storage tanks on farms are smaller than those at service stations and industrial sites, and there are fewer tanks per site on farms. It is estimated that of the Nation's 2.3 million underground fuel tanks, 900,000 are on farms (17).

Extent of the Problem

Approximately 93 percent of all underground fuel storage tanks are made of steel and most have no corrosion protection. The average life of a bare steel tank is 15-20 years (8). Nearly one-third of the tanks now in use are likely to be 20 or more years old (6). Available information suggests that fuel tank leakage may be a significant problem. The Steel Tank Institute estimates that about 100 fuel tank leaks are reported in newspapers across the United States each week (7). Many leaks are not reported, however, and may, in fact, be undetected. New York State has estimated that 19 percent of its underground gasoline tanks leak. Maine estimates that 25 percent of its retail gasoline station tanks have leaks allowing a loss of 11 million gallons annually (10). Versar, Inc., estimates that up to 12 percent of retail gasoline station tanks may leak (17), and some petroleum industry experts estimate that 6-8 percent of all steel tanks without corrosion protection may leak (9).

Most tanks that leak probably cause little, if any, harm. Others, however, can cause extensive damage. Some aquifers that provide drinking water to thousands of people are near the surface and can be contaminated easily. Others may discharge into streams and lakes, and, if contaminated, can in turn contaminate the receiving waters. Small amounts of gasoline and other petroleum products alter the smell and taste of water; large concentrations are toxic. Gasoline also contains additives that are suspected carcinogens.

Decontamination of groundwater, especially in an aquifer, is extremely difficult and may require centuries for nature to restore groundwater quality (12). Once contaminated, alternative sources of drinking water must be located. If leaks are discovered in time, the fuel can be removed from the soil using trenches and wells before it seriously contaminates an aquifer (2). The Steel Tank Institute reports that the average cost of cleanup, excluding legal costs, is $30,000 to $50,000. Cleanup costs were reported to be as high as $12 million in one incident (8).

Regulation of Underground Fuel Storage Tanks

Government regulation of underground storage tanks can take many forms including registration of existing tanks, tank installation permits, equipment specifications, installation procedures, secondary containment requirements, provisions for containment of fuel when tanks are overfilled, maintenance of fuel inventory records, testing or monitoring for leaks, periodic reporting and inspections, and tank abandonment procedures.

The Federal Government presently does not regulate underground fuel storage tanks. State and local governments adhere to regulations promulgated by the National Fire Protection Association, the Uniform Fire Code, or the Building Officials and Code Administrators International to prevent fires and explosions. Sixteen States have adopted, and four additional States are considering, regulations or legislation that call for more stringent standards than those contained in the current fire codes. Table 17 shows the additional standards that each of these States requires or proposes (11).

Table 17.—Key elements of State regulatory programs considered more stringent than the standards of NFPA or UFC[1]

State	Permit requirements	Equipment specifications	Installation procedures	Secondary containment requirements	Replacement requirements	Inventory control requirements	Testing requirements
Arkansas (R)	X	X	—	—	—	—	—
California (L)	X	—	—	X	X	X	X
Colorado (R)	X	X	—	—	—	X	—
Connecticut (D)	P	P	—	—	P	P	P
Delware (R)	X	—	—	—	X	X	X
Florida (D)	P	P	P	P	P	P	P
Georgia (R)	—	X	—	—	—	—	—
Illinois (D)	P	P	—	P	—	P	—
Indiana (R)	X	—	—	—	—	X	X
Kansas (R)	X	—	X	X	—	X	X
Maryland (R & D)	X	X	—	—	X	X	X
Massachusetts (R)	—	X	—	—	—	X	—
Michigan (R)	X	X	X	—	X	X	X
Minnesota (R)	X	—	X	—	—	—	X
New York (L)	X	—	—	—	—	X	X
Ohio (R)	X	—	—	—	—	X	X
Pennsylvania (R)	X	X	X	—	—	X	X
Puerto Rico (R)	X	X	X	X	—	X	—
Texas (R)	—	X	—	—	X	X	—
Wisconsin (R)	X	—	X	—	—	X	X

Table 17—(CONTINUED)

State	Monitoring requirements	System closure procedures	Recordkeeping requirements	Penalty structure
Arkansas (R)	—	—	—	—
California (L)	X	X	X	X
Colorado (R)	X	—	X	X
Connecticut (D)	—	—	P	—
Delaware (R)	—	X	—	—
Florida (D)	P	P	P	—
Georgia (R)	—	—	—	—
Illinois (R)	—	P	—	P
Indiana (R)	—	—	X	—
Kansas (R)	X	—	X	—
Maryland (R & D)	P	—	X	—
Massachusetts (R)	—	X	—	—
Michigan (R)	X	X	X	—
Minnesota (R)	—	—	—	—
New York (L)	X	X	—	—
Ohio (R)	—	—	X	—
Pennsylvania (R)	—	—	X	—
Puerto Rico (R)	X	X	X	—
Texas (R)	—	—	—	—
Wisconsin (R)	X	X	X	X

[1]NFPA is the National Fire Protection Association; UFC is the Uniform Fire Code.

Notes:
- X = in place
- P = proposed requirements
- R = regulation in place
- L = legislation in place
- D = proposed or draft regulation

Source: (11).

More than 60 local governments have specific codes for leaking underground fuel tanks. Local regulation has been especially evident in California, which has about 20 local ordinances. New York has 12; Massachusetts, 6; and Illinois, 5 (4).

Future Regulation

Several industry standards have been developed for the proper construction and use of fuel tanks, including safety precautions when tanks are located near vulnerable water supplies. The EPA also will consider development of tank design and performance standards, and installation procedures (1). Major disagreements do not appear likely regarding proper design and installation of new tanks although there may be disagreement about the need for observation wells, secondary containment, and periodic inspection at specific sites.

However, the major unresolved issue is how to regulate the many existing underground fuel tanks that do not

meet present industry standards for corrosion control and leak detection. Industry representatives do not offer many recommendations here and the EPA wants more information before recommending a particular course of action. The EPA claims it is prepared to protect the public from any hazards that may arise while the agency studies the problem and possible solutions (1). The EPA currently is preparing a Chemical Advisory and an Advance Notice of Proposed Rulemaking (ANPR), and will conduct a national survey of fuel tanks (13).

The Chemical Advisory, to be released this summer, will discuss tank owners' legal liability for a leak, availability of insurance, leak detection methods, and options for repairing and replacing tanks. The Advance Notice of Public Rulemaking will announce that EPA is beginning rulemaking and may require tank owners to maintain records. The ANPR also will describe what EPA knows about hazards of leaking tanks and outline EPA's regulatory options.

The EPA's national survey of fuel tanks will determine the extent of tank leakage in each relevant industry, identify causes of leaks, and obtain other information that could assist in assessing regulatory options. Data will be collected from approximately 1,000 establishments with underground fuel tanks, including about 200 farms and ranches (15).

Congress is holding hearings on leaking fuel tanks and several bills have been introduced to address the hazards these tanks pose. Such bills would require that EPA promulgate regulations covering tank design, construction, location, maintenance, and operation; monitoring and testing for leaks; and tank operators financial responsibility, recordkeeping, and reporting requirements. Most bills would limit the impact on farmers. For example, some would exempt from regulation all farm and residential tanks of 1,100 gallons or less capacity used for storing motor fuel for noncommercial purposes (not for resale). Other bills would only pertain to tanks located on property used primarily for commercial or government purposes.

Compliance with Regulations

The actions and costs required for individuals to comply with current or potential fuel tank regulations are determined by the likelihood of leaks from their existing tanks, and the need for leak detection and prevention, or tank replacement.

Causes of Leaks

Fuel spills from damaged storage tanks and piping usually are discovered promptly. However, slow leaks caused by corrosion of buried facilities can cause considerable damage before detected. Corrosion of steel is an electrochemical process: dissolved salts, moisture (high water table or precipitation), acidity, sulfides, differences in oxygen levels, and the presence of two types of metal can increase the capability of the soil to conduct electrical currents and affect the rate of corrosion (3). The Southeast has the greatest corrosion potential, while the Great Plains and Rocky Mountain regions have the lowest (17).

Leak Detection and Prevention

Careful inventory control can help detect leaks in underground storage tanks, but this is difficult, especially on farms. The most reliable way to detect or confirm leaks is to use one of many available testing devices or services.

One common test is to overfill a tank into a standpipe and observe how much the fuel level in the standpipe changes over a period of up to 12 hours. This test costs about $350 a tank when performed by a commercial firm and is accurate to within 0.05 gallons per hour (17). Another way to detect leaks is to install observation wells at each end of a tank or at two corners of a tank hole excavation, if more than one tank is present.

Secondary containment may be needed to hold fuels until leaks can be detected and the fuels removed. Secondary containment may be accomplished in two basic ways. One is to use double-wall tanks and pipes. The space between the walls is monitored to detect the presence of fuels or groundwater. Double-wall tanks have the same life expectancy as single-wall tanks since they cannot be used if either wall leaks. The second way is to line the inside of the tank with an impervious material such as polyethylene.

Corrosion of steel tanks can be retarded by coating them with coal-tar epoxy or fiberglass. However, if the coating has pinholes or is damaged during transportation and installation, corrosion will concentrate at these points. Tank owners may obtain additional protection (usually for epoxy-coated tanks) by changing the direction of electrical currents in the ground, a process called cathodic protection. Cathodic protection may be achieved by connecting the tank and piping to another metal (called a "sacrificial anode") that has a strong negative charge and will corrode in place of the tank and pipes, or by introducing direct currents from an outside power source into the ground. Fiberglass coated and cathodically protected steel tanks, if properly built, installed, and maintained, should last indefinitely.

Sacrificial anodes (usually magnesium or zinc) have limited capacity to alter electrical currents and, therefore, are best suited for tanks that have a protective coating and only need backup protection. Tanks may be purchased with sacrificial anode systems already attached. An external source of current may be needed to provide adequate cathodic protection if uncoated steel tanks are used, if underground electrical currents are strong, or if a field of tanks and piping is to be protected. The amount of current can be varied as needed to provide sufficient corrosion protection under almost any soil moisture conditions.

Virtually none of the 35,000 underground tanks installed in the United States in 1962 were corrosion resistant. However, more than one-half of the 40,000 underground tanks installed in 1982 had corrosion protection. By 1987, more than 60 percent of new steel tanks will be so protected (8).

Tanks made completely of fiberglass do not need protection against corrosion, but they lack the structural

strength of steel tanks and must be installed carefully. Most existing fiberglass tanks can be damaged by alcohol (ethanol and methanol) some firms use to increase gasoline octane ratings if the amount of alcohol in the blends exceeds legal limits. Some tank manufacturers recently offered fiberglass tanks with improved alcohol resistance, but their effectiveness has not been verified (17).

Costs of Leaks and Compliance with Regulations

Even if leaks do not harm the environment they result in the loss of expensive fuel. A tank that leaks only one cup of fuel per hour would lose more than 500 gallons in a year. Costs of removing leaking fuel from soil and groundwater usually would be shared with the fuel supplier if the supplier owns the tank, as is often the case with farm tanks. Insurance is available in some areas, at a cost of approximately $50 to $250 per farm per year, to cover cleanup costs.

Costs of complying with Government-mandated tank regulations depend on the specific requirements and tank site. Typical costs for different types of tanks are shown in table 18. Shallow observation wells cost about $1,000 each (6). Deeper observation wells with continuous vapor monitoring may cost nearly $9,000 each, and costs of overfill protection usually exceed $1,000 (6). Transportation and installation costs can add $5,000 to $10,000 to the purchase prices of a 10,000 gallon tank (17). Adding double-containment and leak-monitoring installations to meet regulations was estimated to add $10,000 to $40,000 to the cost of a new 10,000 gallon tank in Santa Clara County, California (9). No estimates are available on the costs of complying with other regulatory requirements. Small tanks often are exempt from the regulations, and requirements for existing tanks usually are limited to registration, monitoring, and leak-detection provisions. It is not possible to make an accurate overall estimate of compliance costs for agriculture at this time.

More discussion about groundwater contamination from leaking underground fuel tanks is likely before specific national regulations are implemented. Future issues of this publication will report significant developments.

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Table 18.—Listing of tank costs and warranties

Tank type	Tank prices 1,000 gallons	Tank prices 10,000 gallons	Warranty
	Dollars		
1. Asphalt coated steel	500	3,000	1 yr. unconditional
2. Fiberglass coated steel	1,200	6,000	20-30 yr. unconditional
3. Fiberglass coated, double-walled steel	3,000	14,000	20-30 yr. unconditional
4. Epoxy coated steel, sacrificial anode	900	4,500	20 yr. limited
5. Fiberglass (regular)	1,600	4,500	30 yr. unconditional
6. Fiberglass (alcohol blends)	2,000	5,000	1 yr. unconditional
7. Tank relining (all steel tanks)	1,500	4,500	10 yr. limited warranty

Notes:

1. Unconditional warranty refers to tank replacement and/or repair costs.
2. Limited warranty refers to a pro-rated refund of the purchase price.
3. Regular fiberglass Tank Warranty is based on no more than 10% ethanol blends and no methanol blends.
4. Alcohol blend fiberglass tank refers to unlimited ethanol/methanol blends.
5. Costs and warranties shown are representative of the industry.

Sources: (5,13,14,17).

Energy and Irrigation

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Abstract: Land irrigated with on-farm pumped water increased 7.5 million acres to 42 million acres from 1974 to 1980. Sharply higher energy prices pushed pumping costs during the same period from $527 million to $1.9 billion. Salinity, declining water levels, and rising energy costs are persistent problems, but the outlook for the future may not be as bleak as some have portrayed it. Water distribution facilities are being improved to reduce seepage and salinity problems, and more efficient application techniques are being adopted to reduce water and energy use. The trend in ground-water irrigation will be dictated by economic conditions needed to overcome high energy costs.

Keywords: Groundwater; energy; irrigation; pumping costs; salinity.

Vast amounts of energy are needed to pump water onto irrigated U.S. cropland, and energy needs are increasing as irrigation grows. The importance of irrigation to U.S. agriculture raises concerns about rising energy prices and water quantity and quality. This paper examines the outlook for irrigation given these concerns.

U.S. irrigated crop acres have increased from 7.5 million in 1900 to 49 million in 1982. These acres now account for 16 percent of our harvested cropland (table 19). Sales from irrigated farms total nearly a third of the value of all farm products sold (table 20). Irrigation plays an even more significant regional role (figure 2). Much of the cropland in the Western United States would not be under cultivation without irrigation. In California, which ranks first in value of farm products sold, irrigated farms produce over 98 percent of total crops sold.

Approximately 85 percent of U.S. irrigated acres are located in the 17 arid and semi-arid Western States, where irrigation has been gradually expanding. In parts of the humid Eastern States, supplemental irrigation has been increasing rapidly as farmers attempt to increase returns per acre and reduce weather risks. Rainfall in the East is usually sufficient for crop production, but periodic shortages affect production, and infrequent severe droughts, like the one in 1983, can be catastroph-

Table 19.—Use of irrigation in the United States

Year	Cropland harvested[1]	All land irrigated	Percent irrigated
	Million acres		*Percent*
1900	415[2]	7.5	2
1930	359	19.5	5
1950	344	27.9	8
1978	320	50.8	16

[1]Includes cropland harvested for field crops, vegetables, fruits, nuts, and other speciality crops. [2]Improved cropland—harvested cropland not reported.

Source: (6).

Table 20.—Value of U.S. agricultural products sold

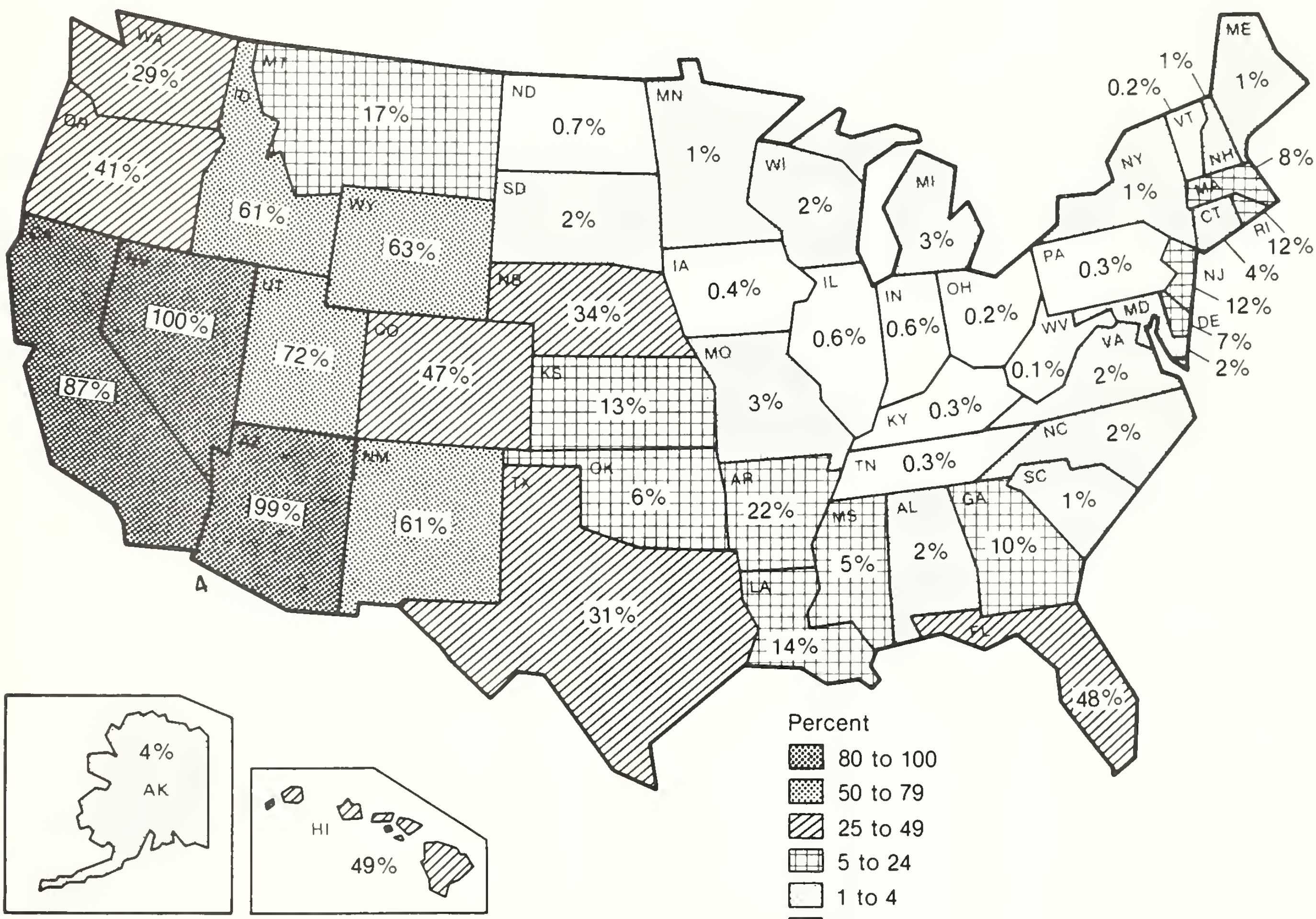
Year	All farms	Irrigated farms[1]	Percent irrigated sales
	Million dollars		*Percent*
1900	2,910	87	3
1930	8,079	900	11
1950	22,052	NA	NA
1978	108,114	31,213	29

[1]Includes production from nonirrigated acres on irrigated farms.

Source: (6).

Figure 2

Irrigated Cropland as a Percent of Total Cropland: 1978



Source: (7)

ic. Supplemental irrigation in the East may increase further.

The expansion of irrigated acreage in the United States has greatly increased the use of water (table 21) and has become a major agricultural resource issue. Among the critical factors for the future of irrigation are the cost of water, the price of energy to pump it, and the quantity and quality of water available for irrigation.

Costs of Irrigation

Irrigation water costs vary widely among locales. Many irrigation projects developed by the Bureau of

Table 21.—Withdrawal of water for irrigation in the United States

Year	Surface water	Groundwater	Total
		Million acre feet	
1950	68	20	88
1955	90	34	124
1960	81	39	120
1965	83	46	129
1970	91	51	142
1975	94	63	157
1980	100	68	168

Source: (10).

Reclamation (BOR) deliver water to farmers under long-term contracts at the subsidized rate of $3 to $4 per acre foot (1). But the cost to the pump irrigator is significantly greater (2). Groundwater in alluvium along rivers and streams is commonly pumped from 20 to 50 feet at the relatively low cost of $8 to $20 per acre foot (based on $.06 per kwh electric rates and gated pipe distribution systems). In much of the Great Plains, from southwest Nebraska through the high plains of Texas, 200 to 300-foot pumping lifts are commonplace; costs run $75 to $110 per acre foot. In some parts of Arizona, 500 to 600-foot pumping lifts are not unusual (2). Variations in pumping lifts result in highly variable groundwater costs.

Climate also influences the cost of irrigation water: In desert areas, water requirements can reach 6 acre feet per acre, while Great Plains water requirements seldom exceed 2 acre feet per acre. In more humid Eastern areas, irrigation rates are often 1 acre foot or less (2).

Energy Use in Irrigation

Five types of energy are used for pumping irrigation water: electricity, diesel, gasoline, natural gas, and liquified petroleum gas (LPG). Electricity is the most widely used because of its availability. It was used on more than 20 million irrigated acres in 1980, up from 15 million acres in 1974 (table 22). The Mountain and

Table 22.—Acreage irrigated with on-farm pumped water using different fuels, by region, 1974 and 1980

Region	Electricity		Diesel		Gasoline		Natural gas		LP gas		Total	
	1974	1980	1974	1980	1974	1980	1974	1980	1974	1980	1974	1980
	1,000 acres											
Northeast	30	25	68	106	176	134	0	41	18	13	292	319
Lake States	296	594	81	424	23	106	0	0	11	29	411	1,153
Corn Belt	71	286	75	429	123	61	2	6	99	145	370	927
Northern Plains	1,573	3,274	1,543	2,792	152	79	2,430	3,621	1,553	1,263	7,251	11,029
Appalachian	105	30	22	139	62	112	1/	2	4	6	193	289
Southeast	585	962	1,045	1,967	189	210	1/	2	222	336	2,041	3,477
Delta States	504	1,572	645	1,197	590	93	205	117	744	58	2,688	3,037
Southern Plains	2,007	2,054	151	166	108	102	6,742	6,204	509	493	9,517	9,019
Mountain	4,297	4,536	307	325	86	147	1,152	1,084	184	196	6,026	6,288
Pacific	6,197	6,745	4	134	0	0	85	85	0	0	6,286	6,964
Alaska	3	2	1/	0	1	1/	0	0	0	0	4	2
Hawaii	72	85	0	0	1/	0	0	0	0	0	72	85
Total	15,740	20,165	3,941	7,679	1,511	1,044	10,615	11,160	3,344	2,539	35,151	42,589

[1]Less than 1,000 acres.

Source: (2).

Table 23.—Quantity of energy used per acre for on-farm pumped irrigated water, by region, 1974 and 1980

Water source and region	Electricity		Diesel		Gasoline		Natural gas		LP gas	
	1974	1980	1974	1980	1974	1980	1974	1980	1974	1980
	Kwh		*Gallons*				*MCF*		*Gallons*	
Groundwater:										
Northeast	427.7	359.3	35.0	35.3	53.3	41.0	0	5.9	63.4	68.1
Lake States	436.6	534.8	42.4	50.1	52.9	57.5	0	0	70.4	77.0
Corn Belt	214.3	320.6	20.9	24.2	30.1	41.7	3.5	2.0	33.1	24.6
Northern Plains	663.8	717.8	62.4	66.7	80.2	81.2	10.5	11.1	98.3	105.1
Appalachian	298.8	364.3	26.8	35.7	30.1	44.7	4.7	5.4	40.6	54.1
Southeast	358.2	708.4	34.0	67.9	45.1	90.0	3.6	0	52.5	88.7
Delta States	287.4	436.3	34.2	41.3	32.9	57.4	4.9	7.1	37.2	60.2
Southern Plains	764.7	817.6	76.9	88.1	93.3	101.5	11.3	12.1	116.6	120.6
Mountain	1438.1	2817.4	159.3	60.5	165.3	90.6	29.3	31.0	253.3	153.7
Pacific	1104.2	1036.6	0	0	0	0	13.7	0	0	0
Alaska and Hawaii	8897.3	9267.3	12.8	0	1049.8	0	0	0	0	0
Surface water:										
Northeast	204.5	202.0	20.6	24.7	23.9	22.2	0	0	34.8	32.6
Lake States	320.8	355.6	26.6	38.7	35.0	44.2	0	0	29.1	48.5
Corn Belt	152.9	291.2	13.7	26.6	20.6	34.9	0	5.5	20.3	42.4
Northern Plains	282.7	552.0	38.5	47.2	19.8	73.7	0	7.4	24.4	61.0
Appalachian	186.2	345.6	18.0	31.1	21.3	36.6	0	3.7	32.9	49.2
Southeast	109.7	314.3	9.2	23.9	25.0	73.1	0	6.2	32.0	93.7
Delta States	102.3	158.7	9.2	15.3	12.2	20.1	1.4	2.6	16.0	21.7
Southern Plains	278.2	288.2	30.3	47.4	32.8	47.8	4.1	4.2	48.1	62.3
Mountain	375.8	782.6	46.7	72.3	55.1	96.0	1.6	3.7	48.0	108.9
Pacific	752.0	816.3	19.2	0	0	0	0	0	0	0
Alaska and Hawaii	740.3	388.1	0	0	10.7	0	0	0	0	0

Source: (2).

Pacific regions accounted for more than half of all acreage irrigated with electricity in 1980.

Where available, natural gas also is used widely; about 11 million acres are irrigated using natural gas-powered pumps in the petroleum-producing Plains and Mountain regions.

The irrigated acreage using diesel fuel for pumping has nearly doubled— from 3.9 million acres in 1974 to about 7.7 million in 1980. Use is concentrated in the Northern Plains, Southeast, and Delta States, where diesel fuel is used mainly for groundwater pumping and where electricity and natural gas are unavailable or more expensive.

Gasoline and LPG were used to pump irrigation water on only 3.5 million acres in 1980, down from about 4.8 million in 1974. These two energy sources are used in regions where other, cheaper fuels are unavailable.

Energy use per acre for on-farm pumped irrigation water (table 23) depends on three factors: (1) distance the water must be lifted from its source to the field, (2) the type of application system used, and (3) the quantity of water applied.

Pumping lifts for surface water are usually shorter than for groundwater, so energy used per acre is less. The exception is the Pacific Northwest, where river water is often pumped to high plateaus. Groundwater pumping lifts vary significantly among the States and regions. Hawaii has very high (700 feet) lifts, as does the Mountain region, thus requiring large energy expenditures per acre.

Water pressure requirements for irrigation distribution systems range from 25-30 pounds per square inch (psi) to over 100 psi. Systems that allow water to flow by gravity have pressure requirements of 0 to 10 psi. Regions with a high percentage of sprinkler irrigation systems—Northeast, Lake States, Southeast, Corn Belt—use more energy per unit of water than regions with a lower concentration of sprinkler systems.

The quantity of water applied also affects energy use per acre simply because of the volume of water that must be pumped. The desert areas of Arizona, California, and Nevada and the dry plains of the Pacific Northwest States require greater energy expenditures for irrigation than does the more humid East.

Per-acre use of energy increased from 1974 to 1980, for three reasons:

- Most of the growth in irrigation (80 percent) was in the use of groundwater rather than surface water; 6 million of the 7.5-million-acre increase was in groundwater irrigation which requires more energy per acre due to higher lifts.
- Groundwater levels are declining in some areas of the Plains and Mountain regions, making the lift greater.
- Much of the newly irrigated land (84 percent) utilizes sprinkler-irrigation systems, which require more energy than gravity-flow systems.

Energy Prices Affect Irrigation Use

On-farm costs of pumping irrigation water have increased from $527 million in 1974 to nearly $1.9 billion in 1980 (the last year these data are available). The 256-percent rise was mostly due to rising energy prices (2). The average cost of energy used in irrigation climbed from $15 per acre in 1974 to $44 in 1980 (2). During this period, higher commodity prices helped offset rising energy prices. However, commodity prices have moderated since 1980, and preliminary data from the 1982 *Census of Agriculture* suggest that irrigated acreage has declined slightly since the 1978 census.

National average prices for electricity, diesel, natural gas, and LPG are shown in table 24. Diesel, natural gas, and LPG prices do not vary much regionally, but significant regional differences are found in the price of electricity. The Pacific Northwest, with a large hydroelectric capacity, supplies power at rates of 1 to 2 cents per kwh, a fraction of what irrigators in other areas pay (2).

Natural gas currently is the cheapest fuel for internal-combustion engines, and it is used extensively for pumping irrigation water in the Great Plains and Mountain regions. Many irrigators using natural gas in this area enjoy a cost advantage over users of diesel, LPG, and electricity. However, recent increases in energy prices are changing the price relationships (table 24). Natural gas price increases brought about by deregulation are making electricity and diesel more competitive.

Between 1974 and 1980, expenditures for electricity increased 224 percent (table 25). They accounted for nearly half of all energy costs incurred for irrigation in 1980. Diesel costs contributed 22 percent to the 1980 total and natural gas another 20 percent. Surface-water pumping costs rose nearly 300 percent from 1974 to 1980 but, amounted to only 11 percent of total on-farm pumping costs in 1980. Total energy expenditures for groundwater pumping rose 3.5 times between 1974 and 1980—from $475 million to nearly $1.7 billion.

Regional changes reveal that pump irrigation costs in the Corn Belt and Lake States grew much faster than in other regions of the country. However, the Northern Plains contributed over half of the new pump-irrigated land. Energy costs for pumping in the Northern Plains and Mountain regions were the greatest of all regions. Although more acres are irrigated with pumped water in the Northern Plains, pumping depths and costs are higher in the Mountain region.

Other Problems

Problems concerning the quantity and quality of irrigation water are currently of high concern. The future availability of good water sources has additional implications for future energy requirements and costs of irrigation.

Quantity of Water

Surface water, the most fully developed source of irrigation water, is replenished by rainfall, snow melt, and seeping groundwater. In some areas, annual surface-

Table 24.—Selected U.S. farm energy prices

Item	Unit	1974	1977	1980	1983	Change 1974-83
		Dollar per unit				*Percent*
Electricity	Kwh	.027	.035	.055	.060	122
Diesel	Gal	.037	.045	1.000	.980	165
LPG	Gal	.300	.390	.620	.770	157
Natural gas[1]	MCF	1.000	1.500	2.500	4.000	300

[1]Estimated by State irrigation specialists.

Sources: (2, 4, 5)

Table 25.—Total cost of energy for on-farm pumped irrigation water, by region, 1974 and 1980

Water source and region	Electricity		Diesel		Gasoline		Natural gas		LP gas		Total	
	1974	1980	1974	1980	1974	1980	1974	1980	1974	1980	1974	1980
	Million dollars											
Groundwater:												
Northeast	0.1	0.3	0.5	2.3	2.1	2.4	0	0.6	0.2	0.1	3.0	5.7
Lake States	1.8	17.1	0.8	16.4	0.4	4.6	0	0	0.1	1.1	3.0	39.2
Corn Belt	0.2	4.3	0.4	8.1	1.3	1.6	0	0	0.7	1.7	2.7	15.7
Northern Plains	19.0	87.3	31.9	169.0	2.7	6.7	19.2	96.9	30.3	68.0	103.0	427.8
Appalachian	1/	0.2	1/	0.4	0.1	0.5	1/	1/	1/	1/	0.2	1.1
Southeast	2.8	25.8	4.7	75.8	2.8	17.1	1/	0	3.7	20.3	14.0	139.0
Delta States	2.4	30.4	5.1	33.5	6.7	3.5	0.5	2.1	7.1	1.6	21.8	71.1
Southern Plains	26.4	61.8	3.0	9.6	3.8	10.0	49.8	168.8	12.6	29.6	95.6	279.8
Mountain	84.1	234.9	9.4	31.6	5.3	5.8	25.8	90.6	6.8	16.4	131.4	379.2
Pacific	79.8	246.1	0.1	17.1	0	0	0.7	7.2	0	0	80.7	270.4
Alaska and Hawaii	19.4	54.3	1/	0	0.4	0	0	0	0	0	19.9	54.3
Total[2]	236.1	762.6	55.9	363.7	25.7	52.1	96.0	366.1	61.7	138.9	475.4	1,683.4
Surface water:												
Northeast	0.9	0.2	0.3	1.2	1.1	2.2	0	0	0.1	0.3	1.6	3.8
Lake States	0.8	2.2	0.3	4.0	0.2	2.0	0	0	1/	0.2	1.3	8.5
Corn Belt	1/	0.5	1/	2.1	0.3	1.2	0	1/	0.2	0.6	0.6	4.5
Northern Plains	0.8	6.3	0.8	10.9	0.8	0.9	0	1.5	2.9	5.1	5.3	24.7
Appalachian	0.4	0.3	0.1	4.1	0.6	4.4	0	1/	1/	0.2	1.2	9.0
Southeast	0.6	4.8	2.3	23.2	0.6	3.2	0	1/	0.2	1.5	3.7	32.7
Delta States	0.3	0.6	0.8	5.4	0.8	0.9	1/	0.2	0.7	0.2	2.7	7.4
Southern Plains	2.8	4.9	0.4	2.8	0.2	0.9	2.7	6.6	1.8	5.2	8.0	20.4
Mountain	9.4	30.0	1.4	5.0	0.5	2.4	1/	1/	0.1	0.8	11.4	38.2
Pacific	16.1	56.7	1/	0	0	0	0	0	0	0	16.1	56.7
Alaska and Hawaii	1/	0.1	0	0	1/	0	0	0	0	0	1/	0.1
Total[2]	31.4	106.5	6.5	58.8	5.1	18.1	2.8	8.5	6.0	14.1	51.9	206.0
Total[2]	267.5	869.0	62.4	422.5	30.8	70.1	98.8	374.6	67.7	153.0	527.3	1,889.0.

[1]Less than $100,000. [2]Totals may not add due to rounding.

Source: (2).

water requirements exceed supplies. Groundwater also is replenished by infiltrating rainfall and snow melt, but in some groundwater irrigation areas, annual use exceeds annual recharge, so groundwater levels are declining.

In most areas of the West, little additional surface water is available for irrigation (figure 3), and what is available would be very expensive to develop (2). Surface water is available for irrigation in the East, and its use has increased, but at a slow rate.

The use of groundwater for irrigation increased 140 percent from 1940 to 1980 (table 21) and this has lowered groundwater levels in several areas (figure 4). Groundwater levels declined on an estimated 15 million acres of irrigated cropland by 1981. As groundwater levels drop, greater energy is required to pump the same volume of water and eventually can become costly enough to force farmers to discontinue irrigation. The High Plains of western Texas is the only large area currently losing irrigated acreage because of declining groundwater levels and prohibitive pumping costs. In the northern Great Plains, Lake States, and the Southeast regions, groundwater irrigation has been expanding. An overall decline in groundwater irrigation in the U.S. as a result of falling water levels is not expected in this century (3).

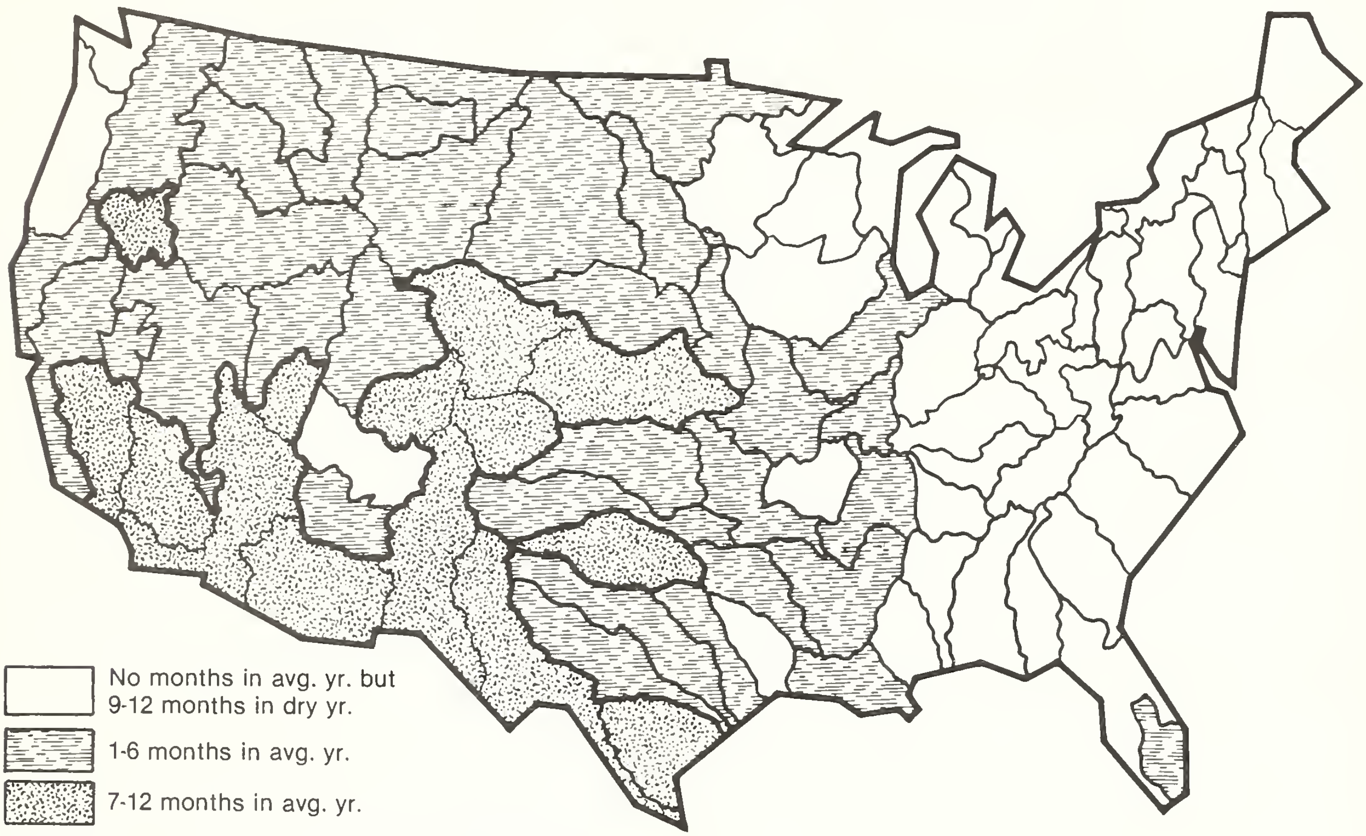
In 1980, surface-water pumping costs were only one-eighth as large as groundwater pumping costs, which totaled 1.7 billion dollars (2). As the use of groundwater for irrigation expands, energy costs for irrigation will continue to increase.

Quality of Water

Salinity is a major surface-water quality problem. Salt concentrations in surface water result from streams passing over saline formations and from return flows of

Figure 3

Number of Months Surface Water Requirements Exceed Surface Water Supplies

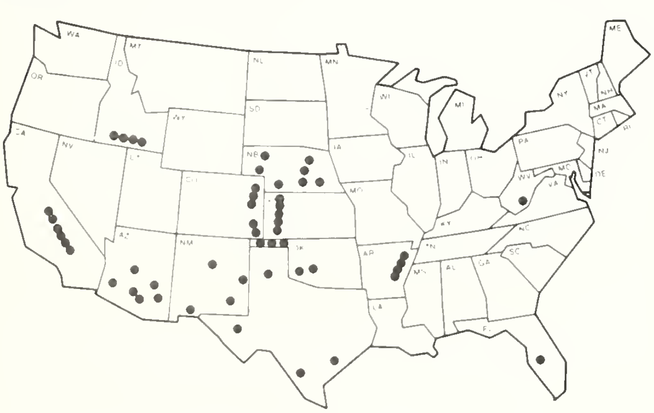


Requirements include both offstream (withdrawal) and instream (flow) requirements.

Source: (11)

Figure 4

Major Groundwater Decline Areas in the United States



Source: (3)

water that have been used for irrigation. Return flows pick up salt from the soil, so that the salt content of the water increases as it flows down river. For example, the salt content of the Colorado River is 20 times higher at the Imperial Dam in Arizona than at its headwaters (12). Salinity problems with groundwater are mainly in California, Texas, and Florida, where pumpage along the sea coasts allows seawater to seep into fresh groundwater supplies.

Water with a relatively high salt content can be used for irrigation if a sufficient quantity is used to flush the salts through the soil into return flows. However, high water tables prevent flushing, and continued use of saline water without extensive drainage networks eventually will do great harm to the soil and prevent crop production. Although this problem exists in several areas of the United States, the largest area affected is about 400,000 acres in the San Joaquin Valley in California (8).

Water management measures to reduce salinity are directed at increasing the efficiency of water use. Irrigation scheduling and other techniques to reduce deep percolation or surface return flows are recommended. As less water is used, the demand for energy used in irrigation pumping is also reduced.

Dealing with the Problems

Many of the problems in irrigated agriculture—overappropriated surface water, declining groundwater levels, salinity, and increasing energy prices—could be reduced by improving the efficiency of distributing,

pumping, and applying irrigation water. Augmenting water supplies by water transfer, weather modification, desalinization of seawater, and water harvesting have been studied, but none appears economically feasible at the present time (1). Some improvements are being made, though.

Irrigation organizations and farmers are improving distribution efficiency by lining canals and ditches or installing pipelines in place of ditches. This reduces deep percolation and evaporation and gives more precise control of water flows. The result is less water withdrawal and, in some cases, reduced salinity. Since less total water must be moved to bring the same effective supply to the field, energy requirements also are proportionately reduced.

Application efficiency appears to be the most promising improvement. Techniques that have been widely adopted in some areas to reduce water application rates without affecting yields include tail-water recovery systems, scheduling water application, improved sprinkler systems, and drip irrigation on perennial crops. Limited application has been made of laser leveling of fields, automated gravity-flow systems, and drip irrigation for annual field crops. These measures to improve application efficiency also reduce energy requirements along with water use.

Research is also in progress to reduce plant water requirements. If plant varieties can be developed that maintain or improve yields while using less water, then use efficiency can be improved and further energy savings are possible. Other attempts to reduce plant water requirements include application of chemicals on leaves to reduce transpiration, various row direction and spacing, and soil mulching techniques.

Recent increases in energy prices have made pump irrigators more aware of pumping costs. It may be possible to improve slightly the mechanical efficiency of pumping plants through design changes. However, much more can be accomplished by proper maintenance and service of existing pumps.

Pump irrigators are applying energy-saving technologies such as low-pressure center pivots, which alone saved about $42 million in 1980. Other energy-saving technologies also are being adopted as commodity prices fail to keep pace with rising energy prices and other production costs.

The future for U.S. cropland irrigation will depend largely on the relative levels of energy and commodity prices and the rate with which more efficient irrigation technologies are adopted. If commodity prices rise at rates equal to or greater than energy prices, or gains in irrigation efficiency continue to be made, irrigated acreage likely will expand, opening new production opportunites on dry U.S. cropland.

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FARM MACHINERY

Spending for farm machinery in 1984 is currently projected to total $8.1 billion, down from the April estimate of $8.6 billion. Total farm machinery purchases for the first 6 months of 1984 are down compared with a year earlier as many farmers continue to experience financial difficulties and face high borrowing costs. While farm wheel tractor purchases increased 3.4 percent over 1983, purchases for other machinery categories fell between 13.6 and 25.6 percent. Prices paid for farm machinery continue to rise faster than prices for all farm production items. Supplies of all machinery items are large.

Demand

Financial Conditions Affecting Farmers

Aggregate U.S. farm machinery expenditures for 1984 currently are projected to rise 2.5 percent in nominal terms from last year's level to $8.1 billion (table 26). Although this increase represents the first positive annual change in total farm machinery expenditures since 1978-79, financial difficulties continue to plague many farmers. A larger than normal proportion of farmers are unable to assume additional long-term debt, and some have partially liquidated farm capital assets to lessen cash-flow problems.

Table 26.—Farm machinery expenditures and factors affecting expenditures

Year	Nominal farm machinery expenditures	Net farm income[1]	January 1: Farm debt[1]	January 1: Real estate assets[1]	January 1: Debt/asset ratio[2]	Interest rates: Prime	Interest rates: PCA
	Billion dollars					Percent	
1978	10.8	18.4	81.6	368.8	16.7	9.1	8.7
1979	12.0	19.8	86.2	400.9	16.1	12.7	10.6
1980	10.9	11.9	92.9	423.7	16.5	15.3	12.7
1981	10.6	15.9	93.3	424.6	16.7	18.9	14.5
1982	8.4	10.8	97.5	395.8	18.6	14.9	14.6
1983[3]	7.9	7-8	100.3	356.8	20.7	10.8	11.5
1984[4]	8.1	13-15	94.7	337.4	20.8	12-13	12.1[5]

[1]Deflated using the GNP implicit price deflator (1972 = 100). [2]Computed based on nominal dollar balance sheet data, including farm households. [3]Preliminary. [4]Projected. [5]Average for first quarter 1984.

The U.S. farm debt/asset ratio (total farm liabilities divided by total farm assets) for January 1, 1984, was estimated to be a record 20.8, up from 20.7 on January 1, 1983. Recent debt/asset ratio estimates indicate that many farmers cannot readily assume increased debt. Although GNP-deflated total farm debt for January 1, 1984, was estimated to have declined 5.6 percent from a year earlier to $94.7 billion (1972 dollars), real land and building assets (which make up a substantial proportion of total farm assets) are estimated to have dropped 5.4 percent to $337.4 billion. In real terms, average U.S. farmland values have declined for the fourth consecutive year.

As a consequence, the rural banking community has been increasingly reluctant to loan additional funds to some farmers, particularly for long-term capital expenditures such as farm machinery. In addition, the Federal Reserve reports that in a survey of banks in the Seventh Reserve District (most of the Corn Belt and Lake States), 60 percent of the bankers reported they refused to provide 1984 operating credit to some farmers financed in 1983.

GNP-deflated net farm income in 1984 is projected to increase substantially from last year to between $13 and $15 billion. Given their debt/asset situation and recent increases in market interest rates, however, many farmers probably will decide not to purchase new capital equipment such as farm machinery. If interest rates increase further during the second half of the year, more farmers probably will elect to pay off outstanding debt with increased income, causing total machinery expenditures for the year to fall below current expectations.

Tractors

Domestic purchases of farm wheel tractors increased to 65,740 units through the first 6 months of 1984, up 3.4 percent from purchases a year earlier (table 27). Two-wheel drive tractor purchases in the under 40 horsepower (hp) and 40-99 hp categories increased 7.5 and 4.6 percent. Meanwhile, two-wheel drive tractor purchases in the 100 hp and over category declined 7.2 percent below 1983, primarily because of a 21.2-percent drop in purchases in May-June 1984 compared with May-June 1983.

Increased tractor purchases in the under 40 hp and a portion of the 40-99 hp categories reflect an actual upturn in demand for small horsepower tractors. However, most of these purchases are for uses other than field crop production. Although sales of 100 hp and over tractors have declined overall, purchases of two-wheel drive 140 hp and over tractors increased 23.2 percent in 1984 over the 6-month 1983 totals. A trend towards front-wheel drive assist accounts for much of this increase in farm demand. Tractors equipped with front-wheel assist drive are available that can provide as much drawbar power as higher priced four-wheel drive units. Front-wheel assist drives offer the convenience of two-wheel drives plus improved fuel efficiency. Recent estimates reported in *Implement and Tractor* indicate that the percentage of 140 hp and over tractors sold with front-wheel assist increased from 1.1 percent in 1978 to 25.5 percent in 1983.

Unlike other tractor categories, farm purchases of four-wheel drive tractors were bolstered primarily by heavy price discounting. Price reductions ranging from 20 to 35 percent were common during the first 6 months of 1984. Consequently, purchases of four-wheel drive tractors rose 12.1 percent to about 2,500 units over the same period last year.

Self-propelled Combines

Although self-propelled combine purchases for May 1984 were 21 percent higher than for May 1983, combine purchases declined 25.6 percent overall during the first 6 months of 1984 compared to the same period last year.

During the first several months of 1983, combine manufacturers offered sales incentives designed to increase sales and reduce inventories. Their efforts were quite successful, with purchases of self-propelled combines increasing 12.6 percent for January-May 1983 from 1982. Incentive programs were scaled down in May 1983 and purchases of new combines in the second half of 1983 fell to their lowest level in several decades. With the incentives ended, higher new combine prices resulted as well as increased purchases of used combines, which further dampened activity in the new combine market.

Other Machinery

Purchases of mower conditioners for January-June 1984 were down 13.6 percent, while purchases of balers (producing under 200 pound bales) and forage harvesters (shear bar) declined 14 and 24.7 percent, respectively,

Table 27.—U.S. tractor and harvesting machinery purchases, January to June, 1983 and 1984

Machine type	1983	1984	Change from 1983 to 1984
	Units		*Percent*
Tractors:			
2-wheel drive—			
Under 40 hp	26,572	28,557	7.5
40-99 hp	20,580	21,518	4.6
100 hp or more	14,160	13,144	−7.2
Total	61,312	63,219	3.1
4-wheel drive	2,248	2,521	12.1
Total	63,560	65,740	3.4
Other machinery:			
Self-propelled combines	4,575	3,403	−25.6
Mower conditioners	8,032	6,936	−13.6
Balers[1]	4,522	3,891	−14.0
Forage harvesters[2]	1,428	1,075	−24.7

[1]Producing 200 pound or smaller bales. [2]Shear bar type.

Source: Farm and Industrial Equipment Institute. *June 1984 FED Flash Report.*.

Table 28.—Indices of U.S. prices paid for farm machinery and other farm production items

Month	Tractors and self-propelled machinery		Other machinery		All farm production items	
	1983	1984	1983	1984	1983	1984
			1977 = 100			
January	168	177	165	174	150	156
March	172	180	168	177	152	157
June	176	182	173	182	153	157
			Percent			
Index increase: June 1983 to June 1984		3.4		5.2		2.6

compared with purchases made from January to June 1983. These more specialized farm machinery items usually are purchased during the second half of the year.

Prices

Farm machinery prices continued to rise faster than prices for all farm production items during the first 6 months of 1984. From June 1983 to June 1984, the price index for tractors and self-propelled machinery, as well as other machinery items, rose 3.4 and 5.2 percent, respectively (table 28). The price index for all farm production items, on the other hand, increased 2.6 percent.

Supplies

Large supplies of all farm machinery items currently are available to U.S. farmers, especially tractors and self-propelled combines. The current supply situation can be expressed by the ratio of inventories to purchases. For a given period, an increase in the ratio of inventories to purchases indicates either declining purchases, increased production, or some combination of the two.

From April 1979 to April 1983, the ratio of inventories as a percent of purchases for all tractors increased dramatically from 120 to 317 (table 29). Likewise, the ratio for self-propelled combines rose from 267 to 545 between April 1980 and April 1982. These supply ratios reflect the decline in farm machinery purchases, slow response in production cutbacks, and increased imports that occurred during the past several years.

To reverse these relationships, farm machinery manufacturers curtailed production and initiated sales incentive programs at various times during the last 3 years. Decreased production and changes in marketing strategies, which increased machinery purchases, reduced April 1984 total tractor inventories below a year earlier. The ratio of inventory to purchases for all two-wheel drive tractors in April 1984 declined from 312 to 274 from a year earlier, while the ratio for four-wheel drive tractors dropped from 393 to 236. The significant drop in the four-wheel drive tractor ratio resulted from increased sales induced by substantial price discounts.

Sales incentive programs during 1983 caused self-propelled combine purchases to rise dramatically, resulting in a large drop in the combine inventory to purchase ratio from 545 to 381. Combine purchases, however, fell last summer when these programs were scaled down. The April 1984 combine ratio rose substantially over last year to 578, reflecting the drop in sales and a resumption in production.

The farm machinery industry currently is operating at approximately 35 and 44 percent of capacity for tractors and combines, respectively (reported in Stark's Newsletter). Most manufacturers are expected to further reduce production this summer to avoid continuing inventory buildups. Also, machinery dealers again are offering attractive sales incentives, such as lower prices and interest rates, delayed financing, and cash rebates, in an effort to boost farm machinery purchases and reduce inventories.

Total farm machinery exports decreased 15.3 percent from $2.38 billion in 1982 to $2 billion in 1983 (table 30). Meanwhile, imports rose 14.2 percent from $1.18 billion in 1982 to $1.35 billion in 1983. The net result was a positive trade balance of $667 million, down from $1.2 billion the previous year. Import increases in

Table 29.—Inventories as a percent of purchases for tractors and self-propelled combines[1]

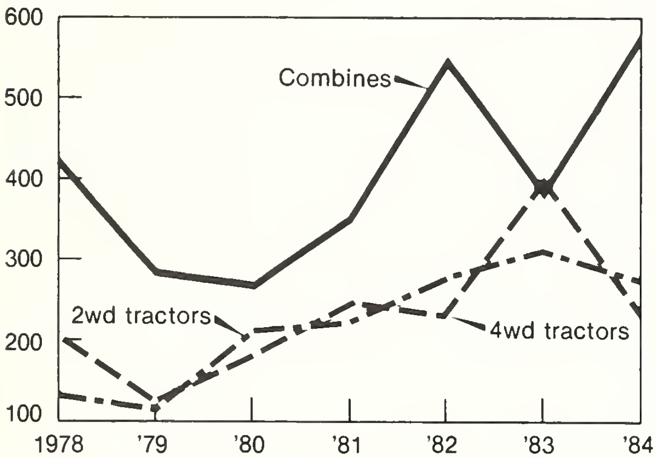
Machine type	1978	1979	1980	1981	1982	1983	1984
				Percent			
Tractors:							
2-wheel drive-							
40-99 hp	148	128	294	260	278	253	217
100 or more hp	109	94	118	174	276	391	354
Total	128	110	209	222	277	312	274
4-wheel drive	203	120	180	244	230	393	236
Total	132	120	208	245	273	317	298
Self-propelled combines	420	283	267	348	545	381	578

[1]April 30 inventories for manufacturers, wholesalers, and dealers divided by January to April purchases.

Source: Farm and Industrial Equipment Institute. *April 1984 U.S. Retail Sales of Wheel Tractors and Selected Farm Machinery.* FED -150-D4-P. June 14, 1984.

Figure 5

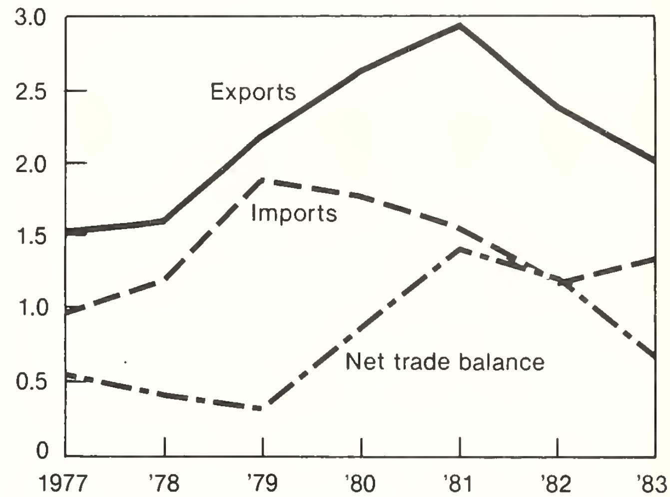
Farm Machinery Inventories[1]



[1]April 30 inventories for manufacturers, wholesalers, and dealers divided by January to April purchases.
Source: Table 29.

Figure 6

U.S. Farm Machinery Trade Balance[1]



[1]Includes finished machinery items, nonassembled machinery, and parts.
Source: Table 30.

Table 30.—U.S. farm machinery and equipment trade balance[1]

Year	Exports	Imports	Trade balance
		Million dollars	
1977	1,518	969	549
1978	1,583	1,183	400
1979	2,187	1,880	307
1980	2,631	1,773	858
1981	2,942	1,550	1,392
1982	2,378	1,180	1,198
1983	2,014	1,347	667

[1]Includes finished machinery items, nonassembled machinery, and parts.

Sources: U.S. Department of Commerce. Bureau of the Census. *Annual Survey of Manufacturers.* M-81- 1981.

______. *Foreign Trade Reports.* FT-246 and FT-446- 1983 and earlier issues.

1983 over 1982 resulted almost entirely from the inflow of 40-99 hp tractors assembled by Western European subsidiaries of U.S. manufacturers.

FERTILIZER

Use

Fertilizer use in 1983/84 still is expected to increase substantially over the 1982/83 lows caused by the PIK-diverted acreage. However, earlier projections of this year's fertilizer use have been modified to reflect the impact of weather.

Spring rains delayed planting and reduced preplant fertilizer applications. However, side dressing of nitrogen fertilizer could offset a part of the preplant reductions. Plant nutrient use appears to be up about 14 percent, to

slightly less than 21 million tons. Nitrogen use appears to be about 10.5 million tons, while phosphate and potash use will be about 4.7 and 5.6 million tons, respectively.

Supplies

Except for nitrogen solutions, fertilizer supplies exceeded use by the end of April 1984. Fertilizer production and imports increased nitrogen supplies 14 percent from a year earlier, while phosphate and potash supplies were up 19 and 10 percent, respectively (table 31). Nitrogen solutions were temporarily in tight supply as wet fields caused some farmers to substitute nitrogen solutions for other materials.

Nitrogen fertilizer production in the first 10 months of 1983/84 was up about 7 percent from a year earlier (table 31). Phosphate production increased 13 percent, while U.S. potash production was down 16 percent. However, potash imports, primarily from Canada, were up 19 percent, making adequate supplies available.

A softening in fertilizer demand because of the late spring caused wholesale prices for nitrogen fertilizer to decline in May and June 1984. These price declines, plus substantial nitrogen imports, appear to have kept the increase in nitrogen production below 10 percent.

Trade

Nitrogen fertilizer imports maintained their substantial margin over year-earlier levels. During July-April 1983/84, nitrogen imports at 3.4 million tons were up 47 percent and exceeded the 2.8 million tons imported in the entire 1982/83 fertilizer year (table 31). Anhydrous ammonia imports were up about 60 percent, while urea imports increased 20 percent. These two products continued to account for the major share of total nitrogen imports.

Table 31.—U.S. fertilizer supplies[1]

Item	1982/83	1983/84	Change
	Million short tons		*Percent*
Beginning inventories:[2]			
Nitrogen (N)	2.07	2.00	−3
Phosphate (P_2O_5)[3]	.68	.67	−1
Potash (K_2O)	.57	.46	−19
Production:			
Nitrogen (N)	9.56	10.16	7
Phosphate (P_2O_5)[3]	7.82	8.83	13
Potash (K_2O)	1.61	1.35	−16
Imports:			
Nitrogen (N)	2.32	3.42	47
Phosphate (P_2O_5)[3]	.11	.09	−18
Potash (K_2O)	3.84	4.56	19
Exports:			
Nitrogen (N)	1.72	1.62	−6
Phosphate (P_2O_5)[3]	3.32	3.15	−5
Potash (K_2O)	.56	.39	−30
Domestic supply:[4]			
Nitrogen (N)	12.23	13.98	14
Phosphate (P_2O_5)[3]	5.29	6.32	19
Potash (K_2O)	5.46	5.98	10

[1]Data for July through April for the fertilizer year starting July 1. [2]As of July 1. [3]Does not include phosphate rock. [4]Includes requirements for industrial uses.

Canada was the major supplier of both anhydrous ammonia and urea imports, while the Soviet Union ranked second. Mexico and Trinidad-Tobago also were important suppliers of nitrogen fertilizer imports.

Nitrogen exports, during July-April 1983/84, were 6 percent below a year earlier. At the end of April, anhydrous ammonia exports were down 13 percent, while urea exports were down 31 percent. However, a 20-percent increase in ammonium sulfate exports and a 10-percent increase in diammonium phosphate exports partially offset the loss.

Total exports of processed phosphatic materials fell 5 percent during July-April 1983/84, led by an 8-percent drop in phosphoric acid and a 29-percent drop in triple superphosphate. Potash imports were 19 percent ahead of a year earlier.

Prices

Farm prices for fertilizer in 1983/84 are up an average of 7 percent from year-earlier levels. Nitrogen prices, which advanced the most, were reported in May to be up 9 percent; phosphate, 8 percent; and potash, 3 percent.

An 18-percent increase in anhydrous ammonia prices contributed the most to nitrogen fertilizer price increases from May 1983 to May 1984 as prices for other nitrogen materials increased from 1 to 8 percent (table 32). Triple superphosphate and diammonium phosphate prices were up 8 and 9 percent, respectively. Potash prices rose 3 percent.

The major share of fertilizer price advances in 1983/84 occurred during December-March in response to PIK-idled acreage returning to production. Weather-related delays in crop plantings and fertilizer applications dampened price advances after March 1984. This, in turn, caused delays in moving fertilizer to fields, which resulted in a buildup of distributor inventories and filled storage facilities to capacity in many cases. The backup of distributors' fertilizer supplies caused wholesale prices to level off or decline late in the spring.

PESTICIDES

U.S. farm demand for pesticides used in the production of major field crops is projected at 506 million pounds active ingredient (a.i.) for the 1984 crop year (table 33). This is down 1 percent from the 512 million pounds projected in March 1984, with herbicides accounting for most of the decrease. The March estimate was based on farmers' February planting intentions, while the current estimate is based on planted acreage as of June 1. The wet weather this spring delayed planting, and many farmers in the Midwest switched from corn to soybeans or did not have their land planted on June 1. In addition, farmers' participation in the Agricultural Programs Adjustment Act of 1984 reduced wheat acreage. Even with the shift in acreages among crops, no shortages of individual pesticide materials have been reported at this time.

Prices

Herbicide prices paid by U.S. field crop farmers declined on average 6 percent from May 1983 to May 1984

Table 32.—Average, May U.S. farm prices paid for selected fertilizer material[1]

Year	Anhydrous ammonia (82%)	Triple superphosphate (44-46%)	Diammonium phosphate (18-46-0%)	Potash (60%)	Mixed fertilizer (6-24-24%)
			Dollar per short ton		
1981	247	249	283	155	226
1982	255	228	262	155	219
1983	237	214	249	143	206
1984	280	231	271	147	217

[1]Based on a survey of fertilizer dealers conducted by the Statistical Reporting Service, USDA.

Table 33.—Pesticide demand by U.S. field crop farmers, 1984

Crop	Planted acres 1983	Planted acres 1984[1]	Herbicides	Insecticides	Fungicides
	Million		Million pounds (a.i.)[2]		
Row:					
Corn	60.2	79.9	237.7	29.4	0.07
Cotton	7.9	11.3	17.3	16.8	0.18
Grain sorghum	11.7	16.2	15.5	2.5	0
Peanuts	1.4	1.5	5.7	1.2	5.63
Soybeans	63.1	68.0	120.1	10.5	0.07
Tobacco	0.8	0.8	1.3	3.1	0.40
Total	145.1	177.7	397.6	63.5	6.35
Small grains:					
Barley and oats	30.7	24.2	6.1	0.2	0
Rice	2.2	2.9	12.1	0.5	0.07
Wheat	76.4	79.5	16.6	2.2	0.92
Total	109.3	106.6	34.8	2.9	0.99
Total	254.4	284.3	432.4	66.4	7.34

[1]Based on a June 1 acreage survey conducted by the Statistical Reporting Service, USDA. [2]Active ingredients.

Table 34.-U.S. average farm retail pesticide prices for May 1982, 1983, and 1984[1]

Pesticides	Price per pound (a.i.)[2] 1982	1983	1984	Change from 1983 to 1984
	Dollars			Percent
Herbicides:				
Alachlor	4.81	5.00	5.25	5.0
Atrazine	2.68	2.50	2.22	−11.2
Butylate+	3.43	3.37	3.46	2.7
Trifluralin	8.55	7.70	6.90	−10.4
2,4-D	2.80	2.64	2.42	−8.3
Composite[3]	4.62	4.58	4.31	−5.9
Insecticides:				
Carbaryl	3.55	3.65	3.75	2.7
Carbofuran	9.56	10.24	10.55	3.0
Methyl parathion	2.60	2.66	2.90	9.0
Synthetic pyrethroids	68.00	58.40	56.00	−4.1
Composite[3]	10.14	9.88	10.00	1.2

[1]Based on a recent survey of pesticide retailers conducted by the Statistical Reporting Service, USDA and other sources. [2]Active ingredients. [3]Weighted average of above compounds and other major pesticide materials not listed.

(table 34). This compares to a projected 7-percent decline made in March for the 1984 crop season. Prices for reported herbicides were about the same or slightly higher in May compared to March 1984, with a composite price of $4.31 a pound a.i. in May and $4.21 a pound a.i. in March.

The composite insecticide price this year is now expected to be up 1 percent over May 1983. This compares to a projected decline reported in March 1984 of over 5 percent for this season. This change results primarily from dynamics in the synthetic pyrethroid market. In March 1984, synthetic pyrethoid prices were projected to drop 16 percent, overshadowing small price increases for corn soil insecticides and general foliar insecticides. The May comparison indicates a decline of only 4 percent for synthetic pyrethroids from a year earlier, while the prices of other reported insecticides were higher than in May 1983.

The relatively new synthetic pyrethroid market is evolving rapidly. Labels of currently used pyrethroid materials are continually being expanded to include more crop-pest sites, new products are gaining a foothold in the market, and several compounds are in the experimental stage. These factors have increased competition in the pyrethroid market and have led to price decreases in recent years. Also in the past, pyrethroid prices generally have declined during the growing season so the extent and intensity of insect infestations during the remainder of the crop year will determine pyrethroid demand and prices.

Regulatory Actions

Ethylene dibromide—The Environmental Protection Agency (EPA) has announced a hearing schedule for ethylene dibromide (EDB) use on felled logs. Information discovery is currently taking place with testimony from witnesses scheduled to start in September 1984.

In its March 2, 1984, Federal Register announcement, EPA deferred a decision on EDB tolerances for selected fruits and vegetables (primarily mangoes) because of a lack of residue data. Data are currently being assembled.

Strychnine—Cancellation hearings on strychnine use are scheduled to start October 15, 1984, in Washington, D.C., with field hearings being conducted later in Rapid City, South Dakota. The pest-sites at issue are prairie dogs and meadow mice in rangeland and pasture. These rodents destroy forage in infested areas, and prairie dog burrows are a hazard to livestock.

Dicofol—Registrants and other interested parties had until May 7, 1984, to submit data to EPA to rebut the presumed risk of DDT-related compounds in dicofol products. EPA is currently reviewing the data and plans to release its findings early this fall. An assessment of all dicofol uses is being prepared by USDA and cooperating States.

Alachlor—Indications are that EPA will soon issue a Special Review notice for the herbicide alachlor (Lasso ®) because it has been shown to produce tumors in laboratory test animals. After the notice is issued, a benefit-risk study will be conducted to evaluate the importance of continued use of alachlor and to develop regulatory options. In terms of quantity applied, alachlor ranked first in use among farm herbicides in 1982, accounting for almost 20 percent of the market. Alachlor is used extensively in corn and soybean production either alone or tank-mixed with other herbicides. It also is registered for use nationally on peanuts, grain sorghum, dry beans, processing green peas, and potatoes, and for cotton in Oklahoma and selected Texas counties.

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